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ATMOSPHERIC EMISSIONS OF ARSENIC, CADMIUM, MERCURY AND ZINC IN EUROPE IN 1982

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SUMMARY

The estimates of atmospheric emissions of arsenic (As), cadmium (Cd), mercury (Hg) and zinc (Zn) from various sources in Europe are presented in this work for 1982. The estimates are based on emission factors and statistical information on the consumption of fossil fuels and the production of industrial goods. The emission factors were estimated separately for different source categories, and in some cases for various production technologies within a given source category or country.

The emission estimates for the European countries are shown below.

Country	Emission, t/y			
	As	Cd	Hg	Zn
Albania	17	< 1	< 1	40
Austria	26	5	1	230
Belgium	85	12	13	700
Bulgaria	147	66	9	1760
Czechoslovakia	94	21	15	760
Denmark	7	6	2	130
Finland	106	8	3	220
France	171	32	17	3640
FRG	351	80	64	6660
GDR	95	37	24	820
Greece	15	3	2	200
Hungary	16	5	3	200
Iceland	< 1	-	-	< 10
Ireland	4	1	< 1	40
Italy	96	36	11	2020
Luxemburg	3	1	-	90
Netherlands	34	6	9	290
Norway	41	2	1	120
Poland	597	180	40	4040
Portugal	11	2	3	100
Romania	116	43	16	720
Spain	263	133	9	3920
Sweden	183	16	7	430
Switzerland	4	1	< 1	60
UK	117	31	38	2300
USSR (Europe)	2098	309	99	13190
Yugoslavia	272	86	7	1940
TOTAL	4972	1123	392	44590

The non-ferrous metal production in smelters is the major emitter of As, Cd and Zn to the atmosphere in Europe. Mercury is mainly emitted from the combustion of coal. These emitters are mainly point sources, and there are regions in Poland, Czechoslovakia, German Democratic Republic, the Soviet Union, Federal Republic of Germany, France, Spain and Italy with large emissions of the above elements. Spatial distributions of the metal emissions in Europe in 1982 are presented within the EMEP grid of 150 km x 150 km.

CONTENTS

ATMOSPHERIC EMISSIONS OF ARSENIC, CADMIUM, MERCURY AND ZINC IN EUROPE IN 1982

1 INTRODUCTION

The objective of this report is to present the atmospheric emissions of arsenic (As), cadmium (Cd), mercury (Hg) and zinc (Zn) from various anthropogenic sources in Europe in 1982. The atmospheric emissions of lead in Europe are presented in a separate report (Pacyna, 1987a).

The emission estimates are based on emission factors and statistical information collected by Pacyna (1987b). The emission factors were estimated separately for different source categories, and in some cases for various production technologies within a given source category or country.

The work is a part of a joint research project with Dornier-System GmbH, funded by Umweltbundesamt in the Federal Republic of Germany (FRG).

2 RESULTS

2.1 ARSENIC

The estimates of the arsenic emissions are given in Tables 1-5. The data show that non-ferrous metal industry, and particularly copper-nickel production is by far the largest emitter of arsenic to the atmosphere in Europe. For some countries, however, the As emissions from fossil-fuel combustion are of equal importance, (e.g., United Kingdom (UK) and Italy).

The estimates in this work can be compared with the estimates of the As emissions in some countries. These are the following:

UK : 117.4 t/y (this work) and
315.0 t/y (Hutton and Symon, 1986)
Sweden: 183.4 t/y (this work) and
130.0 t/y (Naturvårdsverket, 1982 for 1977/78)
FRG : 351.2 t/y (this work) and
500 t/y (Braun et al., 1984).

Major differences exist for UK, and almost exlusively for the As emissions from coal combustion in electric power plants. Ths As emissions from this source in UK by Hutton and Symon (1986) seem to be overestimated. The As content of the British coal does not differ much from the As content of the other European coals. The mean concentrations of As in hard coals burnt in electric power stations in the European Community countries given by Smith (1987) from IEA Coal Research are following: 10 ppm for Denmark, France, Ireland, Italy, Luxemburg and the Netherlands, 14.5 ppm for FRG and 16.8 ppm for UK. Thus, there seems to be no reason to believe that the UK emission factors for electric power plants are much higher than the emission factors for other countries.

The As emission estimates are spatially distributed in the EMEP grid of 150 km x 150 km and shown in Figure 1.

2.2 CADMIUM

The estimates of the cadmium emissions in Europe are given in Tables 6-11. The major source of the Cd emissions in Europe is non-ferrous metal industry, similarly to the atmospheric emissions of arsenic.

There is a small difference between emission data reported earlier by Pacyna (1985) and this survey. This applies for some West European countries, such as Belgium, Finland, France, FRG, Italy, the Netherlands, Norway and UK. During the last few years detailed information become available on the production technologies employed in the non-ferrous metal industry in these countries. This resulted in improved emission factors for heavy metals emmited during roasting, smelting, refining and other processes. Sometimes these factors were estimated for certain plants only (e.g. smelters in FRG).

The estimates in this work can be compared with the estimates of Cd emissions in some countries. These are the following:

UK	: 30.6 t/y (this work) and
	14.0 t/y (Hutton and Symon, 1986)
FRG	: 79.9 t/y (this work) and
	83.6 t/y (UBA, 1977 for 1973)
	83.5 t/y (Sartorius et al., 1977 for 1977)
	78.6-89.6 t/y (EUR, 1981 for 1980)
	79.0 t/y (Schladot and Nürnberg, 1982)
	90.0 t/y (UBA, 1981 for 1981)
Sweden	: 16.4 t/y (this work) and
	12.0 t/y (Naturvårdsverket, 1982 for 1977/78)
Finland	: 8.0 t/y (this work) and
	7.0 t/y (Murkherjee, 1986)
Denmark	: 6.3 t/y (this work) and
	5.0 t/y (Murkherjee, 1986; after National Swedish Environmental Protection Board, 1985)
Norway	: 2.1 t/y (this work) and
	1.7-2.7 t/y (Murkherjee, 1986; after National Swedish Environmental Protection Board, 1985)
the Netherlands:	5.5 t/y (this work) and
	3.8 t/y (Kendall et al., 1985)

The Cd emission estimates are spatially distributed in Figure 2.

2.3 MERCURY

The estimates of the mercury emissions from anthropogenic sources in Europe are presented in Table 12. Combustion of coal is the major contributor to the total emissions of Hg in Europe. This source is followed by the chlor-alkali production.

The estimates in this work can be compared with the estimates of Hg emissions in some countries. These are the following:

UK	:	37.6 t/y (this work) and
		51.0 t/y (Hutton and Symon, 1986)
Sweden	:	7.3 t/y (this work) and
		5.5 t/y (Naturvårdsverket, 1987-data for 1985)
Finland	:	3.0 t/y (this work) and
		1.5 t/y (after Murkherjee, 1986)
the Netherlands:		8.8 t/y (this work) and
		6.0 t/y (ATMOS, 1986).

The spatial distribution of the Hg emissions in Europe in 1982 is shown in Figure 3.

2.4 ZINC

The estimates of the Zn emissions from anthropogenic sources in Europe are presented in Tables 13-18. More than half of the total Zn emission comes from non-ferrous metal industry, and particularly from zinc smelters.

The data from Table 18 can be compared with the national emissions for Sweden and FRG. These are the following:

Sweden:		425.6 t/y (this work) and
		1200.0 t/y (Naturvårdsverket, 1982 for 1977/78) and
		560.0 t/y (Naturvårdsverket, 1987 for 1985)
FRG	:	6663.3 t/y (this work) and
		10000.0 t/y (Braun et al., 1984) and
		7000.0 t/y (Nürnberg et al., 1983).

The spatial distribution of the Zn emissions in Europe in 1982 is presented in Figure 4.

3 GENERAL REMARKS

The data from Table 1-18 show that non-ferrous metal production in smelters is the major emitter of As, Cd and Zn to the atmosphere in Europe. As these emitters are mainly point sources, there are certain regions in Europe with large emission of the above elements. These regions are located mainly in Poland, Czechoslovakia, German Democratic Republic, the Soviet Union, FRG, France, Spain and Italy, as can be seen from Figures 1-5 and Table 19.

It should be noticed, that incomplete emission data are presented for two source categories: waste - related sources and the manufacture and use of the metal - containing products. This is due to the lack of information on the chemical composition of wastes incinerated in some European countries and on the production and use statistics for the metal-containing products.

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Table 1: Arsenic emissions from primary non-ferrous metal industry in Europe in 1982 (t/y).

COUNTRY	Copper-nickel production *1	Lead production *2	Zinc production *3	Mining *4	TOTAL
Albania	15.0			0.2	15.2
Austria	11.3	1.0	1.9	0.2	14.4
Belgium		29.9	24.1		54.0
Bulgaria	77.5	35.4	9.0	1.7	123.6
Czechoslovakia	37.9	6.3	0.2	0.1	44.5
Denmark					-
Finland	82.8		14.4	0.8	98.0
France		43.3	24.4	0.3	68.0
FRG	202.3	33.2	23.5	0.8	259.8
GDR	21.3	15.0	1.7	0.1	38.1
Greece		1.0		0.3	1.3
Hungary	3.3	0.2			3.5
Iceland					-
Ireland				1.5	1.5
Italy		10.9	15.8	0.3	27.0
Luxemburg					-
Netherlands		3.2	18.6		21.8
Norway	30.5		7.9	0.5	38.9
Poland	459.4	23.6	16.5	4.5	504.0
Portugal	5.1				5.1
Romania	50.0	13.7	4.2	0.4	68.3
Spain	168.8	29.9	18.2	2.2	219.1
Sweden	112.4	10.2		2.5	125.1
Switzerland					-
UK		39.3	7.9	0.1	47.3
USSR (Europe)	1550.0	43.7	24.9	12.6	1631.2
Yugoslavia	213.2	24.4	8.7	2.4	249.1
TOTAL	3041.2	364.2	221.9	31.5	3658.8

Notes

*1 Emission factor used: 1250 g/t (Nriagu and Pacyna, 1987).

*2 Emission factor used: 300 g/t (Nriagu and Pacyna, 1987). It was assumed that 30% of total production in the USSR is produced in the European part of the country.

*3 Emission factor used: 100 g/t (Nriagu and Pacyna, 1987). It was assumed that 30% of total production in the USSR is produced in the European part of the country.

*4 Emission factor used: 7.5 g/t (Nriagu and Pacyna, 1987).

Table 2: Arsenic emissions from combustion of fossil fuels in Europe in 1982 (in t/y).

COUNTRY	Electric power plants *1			Industrial, commercial and residential burners *2	TOTAL
	Hard coal	Lignite	Oil		
Albania		0.1		0.8	0.9
Austria	v.l.	0.3	1.1	3.8	5.2
Belgium	3.6		2.0	13.3	18.9
Bulgaria		3.7	1.1	13.0	17.8
Czechoslovakia	2.4	9.7	0.7	20.5	33.3
Denmark	1.5		0.5	2.6	4.6
Finland	0.6		0.6	3.3	4.5
France	4.2	0.3	4.0	21.0	29.5
FRG	6.6	9.4	1.9	27.2	45.1
GDR		22.3		25.8	48.1
Greece		1.5	1.0	2.7	5.2
Hungary	0.2	2.5	0.5	3.9	7.1
Iceland			v.l.	v.l.	-
Ireland	v.l.	0.2	0.1	1.3	1.6
Italy	1.5	0.2	10.6	18.5	30.8
Luxemburg	v.l.		v.l.	0.3	0.3
Netherlands	0.9		2.3	2.7	5.9
Norway	v.l.			v.l.	-
Poland	18.9	7.9		48.6	75.4
Portugal	0.1		0.8	1.5	2.4
Romania		4.3	5.2	21.0	30.5
Spain	2.0	3.7	3.1	11.0	19.8
Sweden	v.l.		0.9	4.5	5.4
Switzerland	v.l.		v.l.	0.9	0.9
UK	15.4		1.6	27.6	44.6
USSR (Europe) *3	65.7	38.0	52.6	101.8	258.1
Yugoslavia		8.8		5.7	14.5
TOTAL	123.6	112.9	90.6	383.3	710.4

Notes

v.l. - very low (below 0.05 t/y).

*1 Emission factors have been calculated by Pacyna (1982).

*2 It was assumed that no significant changes of emissions had occured between 1979 and 1982 from this source. Thus, the 1978/79 data (Pacyna, 1983) were used here.

*3 Two thirds of the total energy production is assumed in the European part of the Soviet Union.

Table 3: Arsenic emissions from production of sinter in iron foundries, cement manufacturing, and combustion of fuel-wood in Europe in 1982 (in t/y).

COUNTRY	Sintering*1	Cement*2 production	Fuel-wood*3 combustion
Albania		0.7	0.4
Austria	3.1	3.0	0.4
Belgium	7.8	3.8	0.2
Bulgaria	1.6	3.4	0.5
Czechoslovakia	9.1	6.2	0.5
Denmark		1.1	0.1
Finland	1.9	1.1	0.9
France	13.5	15.7	2.8
FRG	26.3	18.1	1.1
GDR	1.7	7.0	0.2
Greece		7.7	0.5
Hungary	2.1	2.6	0.8
Iceland		0.1	
Ireland		1.0	v.l.
Italy	11.3	24.2	1.2
Luxemburg	2.6	0.2	v.l.
Netherlands	3.6	1.9	v.l.
Norway	1.1	1.0	0.2
Poland	7.3	9.6	0.7
Portugal	0.2	3.6	0.1
Romania	8.0	8.4	1.2
Spain	6.0	17.8	0.4
Sweden	1.8	1.4	4.7
Switzerland		2.5	0.3
UK	8.3	7.8	v.l.
USSR (Europe)	106.7	49.5	11.3
Yugoslavia	2.5	5.2	1.1
TOTAL	226.5	204.6	29.6

Notes

v.l. - very low (below 0.05 t/y).

*1 Emission factor used: 1 g/t sinter (Nriagu and Pacyna, 1987).

*2 Emission factor used: 0.6 g/t (Nriagu and Pacyna, 1987). It was assumed that two thirds of the total production of cement in the USSR was produced in the European part of the country.

*3 Emission factor used: 0.5 g/t (Pacyna, 1983). The wood density was assumed 546 kg/m^3. It was assumed that a half of the total wood combustion in the USSR took place in the European part of the country.

Table 4: Arsenic emissions from waste-related sources and the manufacture and use of arsenic-containing products in Europe based on national data (in t/y).

COUNTRY	Waste-related sources	Manufacture and use of As-containing products
Albania		
Austria		
Belgium*1	0.3	
Bulgaria		
Czechoslovakia		
Denmark*1	1.3	
Finland		
France*1	2.5	38.5
FRG	0.8*2	
GDR		
Greece*1		0.4
Hungary		
Iceland		
Ireland		
Italy*1	1.3	
Luxemburg		
Netherlands*1	0.9	
Norway		
Poland		
Portugal		
Romania		
Spain		
Sweden*3		45.0
Switzerland		
UK*4	0.6	8.8
USSR (Europe)*1		41.6
Yugoslavia		
TOTAL	7.7	134.3

Notes

*1 Emission data from 1977/1978 (Pacyna, 1983) were accepted assuming only small changes of emissions between 1979 and 1982.

*2 Data from Braun et al. (1984)

*3 Data from Naturvårdsverket (1982) for 1977/1978.

*4 Data from Hutton and Symon (1986).

The emission data for As from waste-related sources and the manufacture and use of arsenic-containing products in Europe are significantly underestimated due to a lack of relevant information for many countries.

Table 5: Arsenic emissions from anthropogenic sources in Europe in 1982 (in t/y).

COUNTRY	Non-ferrous metal industry	Fossil-fuel combustion	Sintering in foundries	Cement production	Fuel-wood combustion	Waste-related sources	Manufacture and use of As - containing products	TOTAL
Albania	15.2	0.9		0.7	0.4			17.2
Austria	14.4	5.2	3.1	3.0	0.4			26.1
Belgium	54.0	18.9	7.8	3.8	0.2	0.3		85.0
Bulgaria	123.6	17.8	1.6	3.4	0.5			146.9
Czechoslovakia	44.5	33.3	9.1	6.2	0.5			93.6
Denmark	-	4.6		1.1	0.1	1.3		7.1
Finland	98.0	4.5	1.9	1.1	0.9			106.4
France	68.0	29.5	13.5	15.7	2.8	2.5	38. 5	170.5
FRG	259.8	45.1	26.3	18.1	1.1	0.8		351.2
GDR	38.1	48.1	1.7	7.0	0.2			95.1
Greece	1.5	5.2		7.7	0.5		0.4	15.1
Hungary	3.5	7.1	2.1	2.6	0.8			16.1
Iceland	-	-		0.1				0.1
Ireland	1.5	1.6		1.0				4.1
Italy	27.0	30.8	11.3	24.2	1.2	1.3		95.8
Luxemburg	-	0.3	2.6	0.2				3.1
Netherlands	21.8	5.9	3.6	1.9		0.9		34.1
Norway	38.9	-	1.1	1.0	0.2			41.2
Poland	504.0	75.4	7.3	9.6	0.7			597.0
Portugal	5.1	2.4	0.2	3.6	0.1			11.4
Romania	68.3	30.5	8.0	8.4	1.2			116.4
Spain	219.1	19.8	6.0	17.8	0.4			263.1
Sweden	125.1	5.4	1.8	1.4	4.7		45.0	183.4
Switzerland	-	0.9		2.5	0.3			3.7
UK	47.3	44.6	8.3	7.8		0.6	8.8	117.4
USSR (Europe)	1631.2	258.1	106.7	49.5	11.3		41.6	2098.4
Yugoslavia	249.1	14.5	2.5	5.2	1.1			272.4
TOTAL	3658.8	710.4	226.5	204.6	29.6	7.7	134.3	4971.9

Table 6: Cadmium emissions from non-ferrous metal production in Europe in 1982 (in t/y).

COUNTRY	Primary zinc	Primary lead	Primary copper	Secondary lead	Secondary copper	TOTAL
Albania						-
Austria	v.l.	0.03	1.8	0.03	0.1	2.0
Belgium	0.05	1.0			2.0	3.1
Bulgaria	45.0	1.2	12.0			58.2
Czechoslovakia	1.2	0.2	5.1	-	-	6.5
Denmark				v.l.		-
Finland	0.03	0.03	4.5		0.2	4.8
France	4.3	1.4		0.2	0.2	6.1
FRG	20.0	1.5	2.1	0.6	0.7	24.9
GDR	8.5	0.5	10.2			19.2
Greece		v.l.				-
Hungary		v.l.	0.5		0.1	0.6
Iceland						-
Ireland						-
Italy	8.6	0.3		0.2	0.1	9.2
Luxemburg						-
Netherlands	0.04	0.1		0.03		0.2
Norway	v.l.		1.5		0.1	1.6
Poland	82.7	0.8	69.6	-	-	153.1
Portugal			0.8		v.l.	0.8
Romania	21.0	0.5	8.0			29.5
Spain	90.9	1.0	27.0	0.1	0.7	119.7
Sweden		0.2	5.6		0.2	6.0
Switzerland						-
UK	3.9	0.7	-	0.4	0.5	5.5
USSR (Europe) *1	124.5	1.4	74.4	0.2		200.5
Yugoslavia	43.4	0.8	34.2		0.5	78.9
TOTAL	454.1	11.7	257.3	1.8	5.4	730.4

Notes
v.l. - very low (below 0.01 g/t).
*1 It was assumed that 30% of the non-ferrous metal production in the USSR takes place in the European part of the country.

Comments
The following emission factors were used:

a) Primary zinc production: 500 g/t for pyrometallurgical process
   0.2 g/t for electrolytical process
b) Primary copper production: 200 g/t
c) Primary lead production: 10 g/t
d) Secondary copper production: 4 g/t
e) Secondary lead production: 2.5 g/t

The above factors were discussed by Pacyna (1986). However, for some countries more information was available on the Cd emissions from particular smelters. Thus, for FRG, the Netherlands and UK the following factors were used:

a) Primary zinc production in the Vertical Retort process (VR): 200 g/t
b) Primary zinc production in the Imperial Smelting Furnace process (ISF): 50 g/t
c) Sintering process in the lead primary production: 5.2 g/t
d) Smelting process in the lead primary production: 0.3 g/t
e) Roasting and smelting processes in the copper production: 10 g/t.

The above factors were discussed by Pacyna (1987c). Finally, the Cd emission factor for primary copper production in the Scandinavian countries was assumed to 62 g/t on the basis of data from Naturvårdsverket (1982).

Table 7: Cadmium emissions from fossil fuel combustion in Europe in 1982 (in t/y).

COUNTRY	Electric power plants *1 t/y			Industrial, commercial and residential burners *2	TOTAL
	Hard coal	Lignite	Oil		
Albania	-	0.03		0.3	0.3
Austria	v.l.	0.1	0.6	1.7	2.4
Belgium	1.2	-	1.0	4.7	6.9
Bulgaria		1.1	0.5	4.9	6.5
Czechoslovakia	0.7	3.0	0.3	7.9	11.9
Denmark	0.5		0.2	1.3	2.0
Finland	0.2		0.3	1.6	2.1
France	1.4	0.1	1.9	9.4	12.8
FRG	12.6	0.2	1.0	19.1	32.9
GDR		6.9		9.4	16.3
Greece		0.5	0.5	1.2	2.2
Hungary	0.1	0.8	0.2	1.6	2.7
Iceland			v.l.	v.l.	-
Ireland	v.l.	0.1	0.1	0.5	0.7
Italy	0.5	0.1	5.0	8.5	14.1
Luxemburg	v.l.		v.l.	0.1	0.1
Netherlands	0.3		1.1	1.1	2.5
Norway	v.l.			v.l.	-
Poland	5.8	2.4		16.3	24.5
Portugal	0.03		0.4	0.8	1.2
Romania		1.3	2.4	7.1	10.8
Spain	0.7	1.2	1.5	4.9	8.3
Sweden	v.l.		0.4	2.6	3.0
Switzerland	v.l.		v.l.	0.4	0.4
UK	4.9		0.8	10.8	16.5
USSR (Europe) *3	20.2	11.8	25.0	26.8	83.8
Yugoslavia		2.7		2.8	5.5
TOTAL	49.1	32.3	43.2	145.8	270.4

Notes

v.l. - very low (below 0.01 t/y).

*1 Emission factors used to calculate the above emissions were the same as in the 1978/1979 emission survey. (Pacyna, 1982), except for FRG (Pacyna, 1987c).

*2 It was assumed that no significant changes had occured for emissions from this source between 1979 and 1982. Thus, the 1978/79 data were used (Pacyna, 1983).

*3 Two thirds of the total energy production is assumed in the European part of the USSR.

Table 8: Cadmium emissions from iron and steel production in Europe in 1982 (in t/y).

COUNTRY	Iron sintering (BOS) *1	Basic oxygen furnace (EAS) *2	Electric arc furnace (OH) *3	Open hearth furnace *4	TOTAL
Albania					
Austria	0.2	0.1	0.2		0.5
Belgium	0.6	0.2	0.3		1.1
Bulgaria	0.1	0.03	0.3	v.l.	0.4
Czechoslovakia	0.7	0.1	1.2	0.2	2.2
Denmark			0.2		0.2
Finland	0.2	0.04	0.2		0.4
France	1.1	0.3	1.4		2.8
FRG	2.5	0.6	2.8		5.9
GDR	0.1	0.02	0.9	0.1	1.1
Greece		v.l.	0.2		0.2
Hungary	0.2	0.02	0.2	0.1	0.5
Iceland					-
Ireland			v.l.		-
Italy	0.9	0.2	5.1		6.2
Luxemburg	0.2	0.1			0.3
Netherlands	0.3	0.2	0.1		0.5
Norway	0.1	v.l.	0.1		0.2
Poland	0.6	0.1	0.9	0.2	1.8
Portugal	0.02	v.l.	0.1		0.1
Romania	0.6	0.1	1.1	0.1	1.9
Spain	0.5	0.1	3.2		3.8
Sweden	0.1	0.04	0.8		0.9
Switzerland		0.01	0.07		0.1
UK	0.7	0.2	1.7		2.6
USSR (Europe)	8.5	0.9	6.6	2.5	18.5
Yugoslavia	0.2	0.03	0.4	0.04	0.7
TOTAL	18.4	3.3	28.0	3.2	52.9

Notes
v.l. - very low (below 0.01 t/y).
The following emission factors were used:
*1 Sinter production : 0.08 g/t
*2 Steel making (BOS): 0.02 g/t
*3 Steel making (EAS): 0.4 g/t
*4 Steel making (OH) : 0.03 g/t

Table 9: Cadmium emissions from waste related sources in Europe - based on national data (in t/y).

COUNTRY	Municipal incineration	Sewage sludge incineration	TOTAL
Albania			
Austria			
Belgium*1			0.8
Bulgaria			
Czechoslovakia			
Denmark*1			3.7
Finland			
France*1			7.4
FRG*2	8	2.4	10.4
GDR			
Greece			
Hungary			
Iceland			
Ireland			
Italy*1			3.9
Luxemburg*1			0.2
Netherlands*3			1.9
Norway*4			0.1
Poland			
Portugal			
Romania			
Spain			
Sweden*5			3.0
Switzerland			
UK*6	5.0	0.2	5.2
USSR (Europe)			
Yugoslavia			
TOTAL			36.6

Notes
*1 Data for 1977 from Hutton (1982)
*2 Data for 1982 from Pacyna (1987c)
*3 Data for 1983/84 from Kendall et al. (1985)
*4 Data from Miljøverndepartementet (1984)
*5 Data for 1977/78 from Naturvårdsverket (1982)
*6 Data for 1983 from Hutton and Symon (1986)

The Cd emissions from waste-related sources are underestimated due to a lack of relevant information from many European countries.

Table 10: Cadmium emissions from production of cement, combustion of fuel-wood, and application of the metal in industry in Europe in 1982 (in t/y).

COUNTRY	Cement production*1	Fuel-wood combustion*2	Industrial application*3
Albania	0.1	0.3	
Austria	0.2	0.2	
Belgium	0.2	0.1	
Bulgaria	0.2	0.3	
Czechoslovakia	0.4	0.3	
Denmark	0.1	0.1	0.2
Finland	0.1	0.6	v.l.
France	0.1	1.7	
FRG	0.6	1.1	4.1
GDR	0.4	0.1	
Greece	0.5	0.3	
Hungary	0.2	0.5	
Iceland	v.l.		
Ireland	0.1	v.l.	
Italy	1.5	0.7	
Luxemburg	v.l.	v.l.	
Netherlands	0.1	v.l.	0.3
Norway	0.1	0.1	
Poland	0.6	0.4	
Portugal	0.2	0.1	
Romania	0.5	0.7	
Spain	1.1	0.2	
Sweden	0.1	2.9	0.5
Switzerland	0.2	0.2	
UK	0.5	v.l.	0.3
USSR (Europe)	3.1	3.4	
Yugoslavia	0.3	0.6	
TOTAL	12.4	14.9	5.4

Notes
v.l. - very low (below 0.01 t/y)

The following emission factors were used:
*1 Cement production: 0.037 g/t except for FRG 0.02 g/t.
It was assumed that two thirds of the total production of cement in the USSR is produced in the European part of the country.
*2 Fuel-wood combustion: 0.3 g/t.
It was assumed that a half of total wood combustion in the USSR takes place in the European part of the country.
Wood density assumed to 546 kg/m^3.
*3 Stabilizer production: 116 g/t Cd charged
Pigment production : 212 g/t Cd charged
Ni-Cd batteries : 860 g/t Cd charged
The Cd emissions for the Netherlands were obtained from Kendall et al. (1985), for Sweden from Naturvårdsverket (1982) and for FRG from Pacyna (1987c). The emissions from this source are underestimated due to lack of statistics on the production of stabilizers, pigments and Ni-Cd batteries in many European countries.

Table 11: Cadmium emissions from anthropogenic sources in Europe in 1982 (in t/y).

COUNTRY	Non-ferrous metal industry	Fossil-fuel combustion	Iron and steel manufacturing	Waste-related sources	Cement production	Fuel-wood combustion	Industrial application	TOTAL
Albania	-	0.3	-	-	0.1	0.3	-	0.7
Austria	2.0	2.4	0.5	-	0.2	0.2	-	5.3
Belgium	3.1	6.9	1.1	0.8	0.2	0.1	-	12.2
Bulgaria	58.2	6.5	0.4	-	0.2	0.3	-	65.6
Czechoslovakia	6.5	11.9	2.2	-	0.4	0.3	-	21.3
Denmark	-	2.0	0.2	3.7	0.1	0.1	0.2	6.3
Finland	4.8	2.1	0.4	-	0.1	0.6	-	8.0
France	6.1	12.8	2.8	7.4	1.0	1.7	-	31.8
FRG	24.9	32.9	5.9	10.4	0.6	1.1	4.1	79.9
GDR	19.2	16.3	1.1	-	0.4	0.1	-	37.1
Greece	-	2.2	0.2	-	0.5	0.3	-	3.2
Hungary	0.6	2.7	0.5	-	0.2	0.5	-	4.5
Iceland	-	-	-	-	-	-	-	-
Ireland	-	0.7	-	-	0.1	-	-	0.8
Italy	9.2	14.1	6.2	3.9	1.5	0.7	-	35.6
Luxemburg	-	0.1	0.3	0.2	-	-	-	0.6
Netherlands	0.2	2.5	0.5	1.9	0.1	-	0.3	5.5
Norway	1.6	-	0.2	0.1	0.1	0.1	-	2.1
Poland	153.1	24.5	1.8	-	0.6	0.4	-	180.4
Portugal	0.8	1.2	0.1	-	0.2	0.1	-	2.4
Romania	29.5	10.8	1.9	-	0.5	0.7	-	43.4
Spain	119.7	8.3	3.8	-	1.1	0.2	-	133.1
Sweden	6.0	3.0	0.9	3.0	0.1	2.9	0.5	16.4
Switzerland	-	0.4	0.1	-	0.2	0.2	-	0.9
UK	5.5	16.5	2.6	5.2	0.5	-	0.3	30.6
USSR (Europe)	200.5	83.8	18.5	-	3.1	3.4	-	309.3
Yugoslavia	78.9	5.5	0.7	-	0.3	0.6	-	86.0
TOTAL	730.4	270.4	52.9	36.6	12.4	14.9	5.4	1123.0

Table 12: Emission factors and emissions of mercury from anthropogenic sources in Europe in 1982.

COUNTRY	Hard coal combustion in el.p.plants: E.factor, µg/TJ [*1]	Hard coal combustion in el.p.plants: Emission, t/y	Lignite comustion in el.p.plants: E.factor, µg/TJ [*1]	Lignite comustion in el.p.plants: Emission, t/y	Combustion of coal in in industrial, residential and commercial furnances, t/y [*2]	Roasting and smelting, t/y [*3]: Pb production	Roasting and smelting, t/y [*3]: Zn production	Waste-related sources t/y [*6]	Combustion of fuel-wood t/y [*4]	Chlor-alkali production t/y [*5]	TOTAL t/y
Albania			19.0	v.l.	0.4				0.2		0.6
Austria	9.5	v.l.	9.5	0.2	0.4	v.l.	0.2		0.3		1.1
Belgium	24.7	1.4			5.7	0.3	1.9	0.2	0.1	3.0	12.6
Bulgaria			24.7	1.5	5.3	0.4	0.7		0.2	0.5	8.6
Czechoslovakia	22.8	1.0	26.6	4.1	8.0	0.1	v.l.		0.2	1.5	14.9
Denmark	9.5	0.7			0.2			1.0	v.l.	0.1	2.0
Finland	9.5	0.2			0.2		1.2		0.4	1.0	3.0
France [*7]	7.6	1.5	13.3	0.1	3.2	0.4	2.0	1.9	1.1	6.5	16.7
FRG		10.7		11.0	9.3	0.8	3.0	12.8	1.1	15.6	64.3
GDR			28.5	9.3	11.4	0.2	0.1		0.1	2.6	23.7
Greece			15.2	0.7	0.6	v.l.			0.2		1.5
Hungary	17.1	0.1	24.7	1.1	1.3				0.3	0.1	2.9
Iceland					v.l.						v.l.
Ireland	9.5	v.l.	20.9	0.2	v.l.				v.l.		0.2
Italy	9.5	0.6	20.9	0.1	3.2	0.1	1.3	1.0	0.5	4.0	10.8
Luxemburg	9.5	v.l.			v.l.				v.l.		v.l.
Netherlands	9.5	0.4			1.0	v.l.	1.5	4.0	v.l.	1.9	8.8
Norway	9.5	v.l.			v.l.		0.6	0.1	0.1	0.5	1.3
Poland	22.8	7.6	41.8	3.5	25.7	0.2	1.3		0.3	1.4	40.0
Portugal	11.4	v.l.			0.2				0.1	2.3	2.6
Romania			30.4	1.9	11.0	0.1			0.5	2.6	16.1
Spain	11.4	1.0	20.9	1.6	2.1	0.3	1.5		0.2	2.6	9.3
Sweden	9.5	v.l.			0.4	0.1		3.5	1.9	1.4	7.3
Switzerland	11.4	v.l.			v.l.				0.1		0.1
UK	22.8	14.7			5.7	0.4	0.6	6.5	v.l.	9.7	37.6
USSR (Europe)	22.8	26.2	34.2	16.4	36.7	0.4	2.0		4.6	13.0	99.3
Yugoslavia			30.4	3.8	0.8	0.2	0.7		0.4	0.6	6.5
TOTAL		66.1		55.5	132.8	4.0	18.6	31.0	12.9	70.9	391.8

Notes

v.l. - very low (below 0.05 t/y).

*1 Emission factors were calculated by Pacyna (1982). It was assumed that 95% of Hg enters the atmosphere as a vapour. Two thirds of the total energy production in the USSR is produced in the European part of the country.

*2 These data were obtained from Pacyna (1983). It was assumed that similar amounts of Hg were emitted into the atmosphere from combustion of coal in industrial, residential and commercial furnances in 1978/1979 and in 1982.

*3 The following emission factors were used:
a) For primary lead production: 3 g/t Pb produced.
b) For primary zinc production: 8 g/t Zn produced.
It was assumed that 30% of the total lead and zinc production in the USSR is produced in the European part of the country.

*4 An emission factor of 0.2 g/t was used and wood density was assumed to 546 kg/m^3. It was also assumed that a half of total wood combustion in the USSR takes place in the European part of the country.

*5 An emission factor of 5.2 g/t Cl_2 produced was used for most of the countries except for:
a) UK (Hutton and Symon, 1986)
b) the Netherlands (ATMOS, 1986).

*6 The data were obtained from Pacyna (1983) and are representative for 1979, assuming only small changes between emissions in 1979 and 1982. However, for some countries national data were accepted:
a) the Netherlands (ATMOS, 1986)
b) Norway (Miljøverndepartementet, 1984)
c) Sweden (Naturvårdsverket, 1987)
d) UK (Hutton and Symon, 1986).

*7 Emission data from Pacyna (1987c).

Table 13: Zinc emissions from non-ferrous metal production in Europe in 1982 (in t/y).

COUNTRY	Mining *1	Primary production			Secondary production			TOTAL
		Copper *2	Lead *3	Zinc *4	Copper *5	Lead *6	Zinc *7	
Albania	1.7	10.1						11.8
Austria	2.1	7.6	0.4	0.1	16.3	3.2	7.2	36.9
Belgium			11.0	1.5	250.1			262.6
Bulgaria	17.3	52.4	13.0	1414.8	30.0			1527.5
Czechoslovakia	1.0	25.6	2.3	37.7	12.8			79.4
Denmark						4.8		4.8
Finland	7.1	55.9		0.9	24.0			87.9
France	3.2		15.9	2554.0	22.8	23.0		2618.9
FRG	8.4	136.7	12.2	1548.0	196.8	76.6	2770.2	4748.9
GDR	1.2	14.4	5.5	267.2	25.5			313.8
Greece	2.9		0.4					3.3
Hungary	0.1	2.2	0.1		11.4			13.8
Iceland								-
Ireland	15.4							15.4
Italy	3.3		4.0	592.2	9.8	29.2		638.5
Luxemburg								-
Netherlands			1.2	1.2				2.4
Norway	4.8	20.6		0.5	12.0			37.9
Poland	44.7	310.5	8.7	2600	174.0			3137.9
Portugal	v.l.	3.5			2.3			5.8
Romania	4.3	33.8	5.0					43.1
Spain	21.6	114.1	11.0	2857.9	86.0	9.6		3100.2
Sweden	25.2	76.0	3.8		31.2			136.2
Switzerland								-
UK	1.0		14.4	1246.6	67.1	52.6	171.0	1552.7
USSR (Europe)	113.9	1047.8	16.0	3914.3	745.0	73.5	810.0	6720.5
Yugoslavia	23.7	144.4	8.9	1364.5	63.5			1605.0
TOTAL	302.9	2055.6	133.8	18401.4	1780.6	272.5	3758.4	26705.2

Notes

v.l. - very low (below 0.05 t/y)

*1 Emission factor used: 75 g/t (Zn+Cu+Pb) mined on the basis of review by Nriagu and Pacyna (1987).

*2 Emission factor used: 845 g/t as in the previous report by Pacyna (1983).

*3 Emission factor used: 110 g/t as in the previous report by Pacyna (1983).
It is assumed that 30% of the total production of lead in the USSR was produced in the European part of the country.

*4 Emission factor used: 15720 g/t for pyrometallurgical plants (Pacyna, 1983)
6.3 g/t for electrolytical plants.
It is assumed that 30% of the total production of zinc in the USSR was produced in the European part of the country.

*5 Emission factor used: 500 g/t (Pacyna, 1986)

*6 Emission factor used: 300 g/t (Pacyna, 1983)

*7 Emission factor used: 9000 g/t (Pacyna, 1986)

Table 14: Zinc emissions from fossil fuel combustion in Europe in 1982 (in t/y).

COUNTRY	Power plants *1			Industrial, commercial and residential burners *2	TOTAL
	Hard coal	Lignite	Oil		
Albania		0.5		3.6	4.1
Austria	0.1	1.7	4.2	16.3	22.3
Belgium	18.1		7.3	65.7	91.1
Bulgaria		18.7	3.9	60.8	83.4
Czechoslovakia	12.2	48.8	2.5	94.8	158.3
Denmark	7.6		1.7	10.1	19.4
Finland	3.0		2.1	13.9	19.0
France	20.9	1.6	14.7	90.0	127.2
FRG	32.7	46.9	7.0	123.9	210.5
GDR		110.9		122.7	233.6
Greece		7.4	3.5	10.8	21.7
Hungary	1.2	12.8	1.8	17.7	33.5
Iceland			v.l.	v.l.	
Ireland	v.l.	1.1	0.5	6.0	7.6
Italy	7.4	1.2	35.2	75.6	119.4
Luxemburg	v.l.		0.1	1.4	1.5
Netherlands	4.4		8.3	12.3	25.0
Norway	0.1			5.4	5.5
Poland	95.4	39.7		241.9	377.0
Portugal	0.4		2.8	5.8	9.0
Romania		21.8	18.6	104.4	144.8
Spain	10.1	18.5	11.3	46.6	86.5
Sweden	v.l.		3.2	20.1	23.3
Switzerland	v.l.		0.1	3.2	3.3
UK	77.2		5.9	138.1	221.2
USSR (Europe)	331.0	191.4	190.5	462.7	1175.6
Yugoslavia		44.2		22.8	67.0
TOTAL	621.8	567.2	325.2	1776.6	3290.8

Notes

v.l. - very low (below 0.05 t/y).

*1 Emission factors used to calculate the above emissions were the same as in the previous emission survey (Pacyna, 1982).

*2 It was assumed that no significant changes of emissions had occured between 1979 and 1982 from this source. Thus, the 1978/79 data were used (Pacyna, 1983).

*3 Two thirds of the total energy production in the USSR is assumed in the European part of the country.

Table 15: Zinc emissions from iron and steel production in Europe in 1982 (in t/y).

COUNTRY	Iron sintering *1	Basic oxygen furnace *2	Electric arc furnace *3	Open hearth furnace *4	TOTAL
Albania					
Austria	83.7	14.9	10.9		109.5
Belgium	210.7	35.8	21.7		268.2
Bulgaria	43.2	5.4	24.4	1.9	74.9
Czechoslovakia	245.7	23.4	81.0	39.0	389.1
Denmark			28.5		28.5
Finland	51.4	7.8	10.9		70.1
France	364.5	57.8	97.2		519.5
FRG	710.0	112.6	189.0		1011.6
GDR	45.8	3.9	59.3	24.8	133.8
Greece		2.0	13.5		15.5
Hungary	56.7	5.1	10.9	13.0	85.7
Iceland					
Ireland			1.7		1.7
Italy	305.2	44.1	342.8		692.1
Luxemburg	70.2	13.7			83.9
Netherlands	97.2	16.3	5.3		118.8
Norway	29.7	1.5	8.2		39.4
Poland	197.2	24.6	59.3	41.2	322.3
Portugal	5.3	0.7	8.2		14.2
Romania	216.0	24.9	72.8	26.0	339.7
Spain	162.0	20.7	213.4		396.1
Sweden	48.7	7.3	54.0		110.0
Switzerland		2.7	5.3		8.0
UK	224.2	36.3	118.9		379.4
USSR (Europe)	2881.2	181.4	445.6	545.2	4053.4
Yugoslavia	102.7	5.9	27.0	8.4	144.0
TOTAL	6151.3	648.8	1909.8	699.5	9409.4

Notes
Emission factor used:
*1 27.0 g/t sinter
*2 3.9 g/t steel
*3 27.0 g/t steel
*4 6.5 g/t steel

Table 16: Zinc emissions from production of cement and phosphate fertilizers, and combustion of fuel-wood in Europe in 1982 (in t/y).

COUNTRY	Cement*1 production	Phosphate fertilizer production	Fuel-wood*3 combustion
Albania	12.0	0.4	8.8
Austria	55.1	1.5	7.8
Belgium	69.5		3.1
Bulgaria	61.8	3.7	9.5
Czechoslovakia	113.6	5.1	9.6
Denmark	19.5	2.1	2.0
Finland	21.0	0.2	18.4
France	287.6	27.5	56.5
FRG	330.9	2.5	22.9
GDR	128.9	4.2	4.1
Greece	141.5	2.2	10.9
Hungary	48.1	2.4	15.8
Iceland	1.4		
Ireland	17.8	0.6	0.3
Italy	442.7	2.2	24.6
Luxemburg	3.8		0.1
Netherlands	34.1	2.7	0.5
Norway	18.7		4.4
Poland	176.4	9.0	14.6
Portugal	65.4	1.5	2.3
Romania	153.2	11.5	24.9
Spain	325.6	1.5	7.7
Sweden	25.3	0.7	95.1
Switzerland	45.1	0.1	5.3
UK	142.6	1.3	0.8
USSR (Europe)	907.0	108.0	227.4
Yugoslavia	95.7	2.1	21.6
TOTAL	3744.3	193.0	599.0

Notes

*1 Emission factor used: 11 g/t (Nriagu and Pacyna, 1987). It is assumed that two thirds of the total production of cement in the USSR was produced in the European part of the country.

*2 Emission factor used: 15.3 g/t (Pacyna, 1983).

*3 Emission factor used: 10.0 g/t (Nriagu and Pacyna, 1987). The wood density is assumed 546 kg/m^3. A half of the total wood combustion in the European part of the country.

Table 17: Zinc emissions from waste related sources in Europe (in t/y).

COUNTRY	Municipal and sewage sludge incineration
Albania	
Austria	
Belgium	
Bulgaria	
Czechoslovakia	
Denmark*5	52.5
Finland	
France	
FRG*1	336.0
GDR	
Greece	
Hungary	
Iceland	
Ireland	
Italy*2	103.2
Luxemburg*2	4.1
Netherlands*2	110.4
Norway*3	11.2
Poland	
Portugal	
Romania	
Spain	
Sweden*4	35.0
Switzerland	
UK	
USSR (Europe)	
Yugoslavia	
TOTAL	652.4

Notes

*1 Data from Braun et al. (1984)

*2 Data calculated on the basis of the FRG emissions. The chemical composition of waste input to incinerators in Italy, the Netherlands and Luxemburg was similar to that in FRG (after Rentz et al., 1982).

*3 On the basis of data from Miljøverndepartementet (1984).

*4 Data from Naturvårdsverket (1982)

*5 Data calculated on the basis of the Swedish data.

Table 18: Zinc emissions from anthropogenic sources in Europe in 1982 (in t/y).

COUNTRY	Non-ferrous metal industry	Fossil-fuel combustion	Iron and steel production	Cement production	Phosphate fertilizer production	Fuel-wood combustion	Waste-related sources	TOTAL
Albania	11.8	4.1		12.0	0.4	8.8		37.1
Austria	36.9	22.3	109.5	55.1	1.5	7.8		233.1
Belgium	262.6	91.1	268.2	69.5		3.1		694.5
Bulgaria	1527.5	83.4	74.9	61.8	3.7	9.5		1760.8
Czechoslovakia	79.4	158.3	389.1	113.6	5.1	9.6		755.1
Denmark	4.8	19.4	28.5	19.5	2.1	2.0	52.5	128.8
Finland	87.9	19.0	70.1	21.0	0.2	18.4		216.6
France	2618.9	127.2	519.5	287.6	27.5	56.5		3637.2
FRG	4748.9	210.5	1011.6	330.9	2.5	22.9	336.0	6663.3
GDR	313.8	233.6	133.8	128.9	4.2	4.1		818.4
Greece	3.3	21.7	15.5	141.5	2.2	10.9		195.1
Hungary	13.8	33.5	85.7	48.1	2.4	15.8		199.3
Iceland				1.4				1.4
Ireland	15.4	7.6	1.7	17.8	0.6	0.3		43.4
Italy	638.5	119.4	692.1	442.7	2.2	24.6	103.2	2022.7
Luxemburg		1.5	83.9	3.8		0.1	4.1	93.4
Netherlands	2.4	25.0	118.8	34.1	2.7	0.5	110.4	293.9
Norway	37.9	5.5	39.4	18.7		4.4	11.2	117.1
Poland	3137.9	377.0	322.3	176.4	9.0	14.6		4037.2
Portugal	5.8	9.0	14.2	65.4	1.5	2.3		98.2
Romania	43.1	144.8	339.7	153.2	11.5	24.9		717.2
Spain	3100.2	86.5	396.1	325.6	1.5	7.7		3917.6
Sweden	136.2	23.3	110.0	25.3	0.7	95.1	35.0	425.6
Switzerland		3.3	8.0	45.1	0.1	5.3		61.8
UK	1552.7	221.2	379.4	142.6	1.3	0.8		2298.0
USSR (Europe)	6720.5	1175.6	4053.4	907.0	108.0	227.4		13191.9
Yugoslavia	1605.0	67.0	144.0	95.7	2.1	21.6		1935.4
TOTAL	26705.2	3290.8	9409.4	3744.3	193.0	599.0	652.4	44594.1

Table 19: Anthropogenic emissions of arsenic, cadmium, mercury, lead and zinc in Europe in 1982 (in t/y).

COUNTRY	As	Cd	Hg	Pb	Zn
Albania	17.2	0.7	0.6	136	37
Austria	26.1	5.3	1.1	1123	233
Belgium	85.0	12.2	12.6	2097	695
Bulgaria	146.9	65.6	8.6	1580	1761
Czechoslovakia	93.6	21.3	14.9	1129	755
Denmark	7.1	6.3	2.0	653	129
Finland	106.4	8.0	3.0	1122	217
France	170.5	31.8	16.7	8684	3637
FRG	351.2	79.9	64.3	5562	6663
GDR	95.1	37.1	23.7	1751	818
Greece	15.1	3.2	1.5	1393	195
Hungary	16.1	4.5	2.9	596	199
Iceland	0.1	-	-	39	1
Ireland	4.1	0.8	0.2	438	43
Italy	95.8	35.6	10.8	8604	2023
Luxemburg	3.1	0.6	-	166	93
Netherlands	34.1	5.5	8.8	2205	294
Norway	41.2	2.1	1.3	727	117
Poland	597.0	180.4	40.0	3003	4037
Portugal	11.4	2.4	2.6	381	98
Romania	116.4	43.4	16.1	1156	717
Spain	263.1	133.1	9.3	4201	3918
Sweden	183.4	16.4	7.3	1053	426
Switzerland	3.7	0.9	0.1	450	62
UK	117.4	30.6	37.6	8614	2298
USSR (Europe)	2098.4	309.3	99.3	30928	13192
Yugoslavia	272.4	86.0	6.5	1962	1935
TOTAL	4971.9	1123.0	391.8	89753	44593

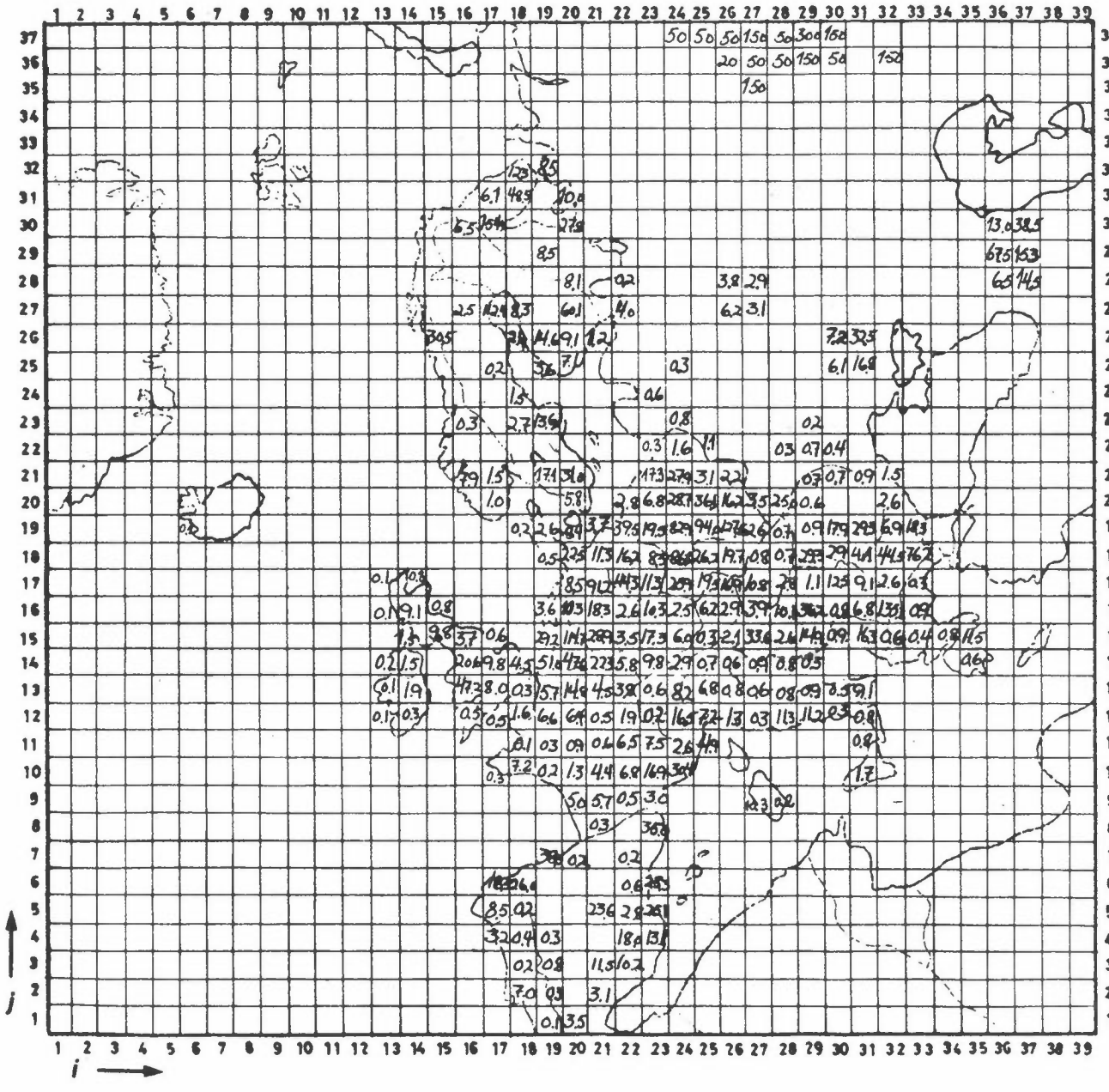

Figure 1: Spatial distribution of the As emissions in Europe in 1982 within the EMEP grid of 150 km x 150 km.

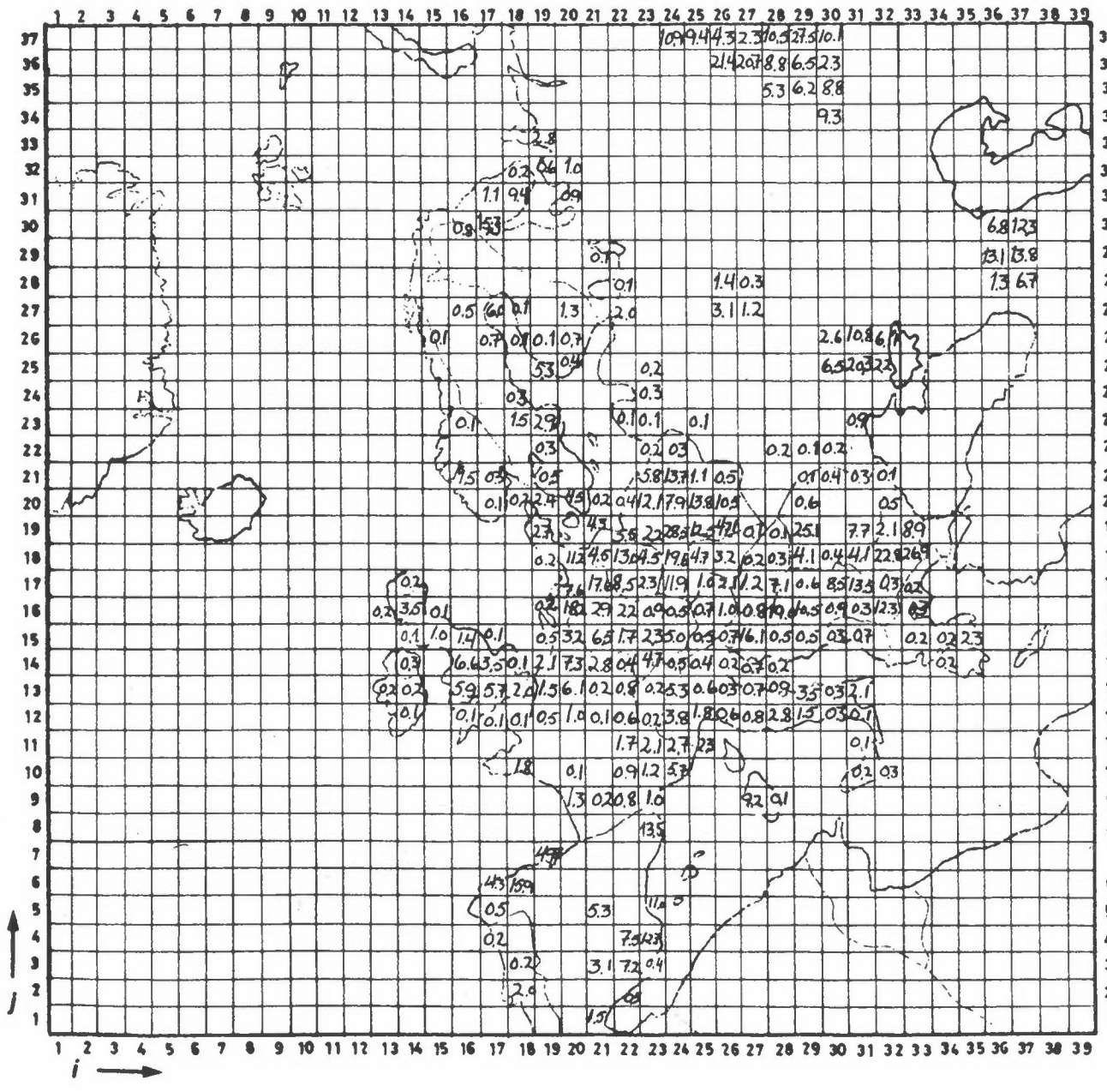

Figure 2: Spatial distribution of the Cd emissions in Europe in 1982 within the EMEP grid of 150 km x 150 km.

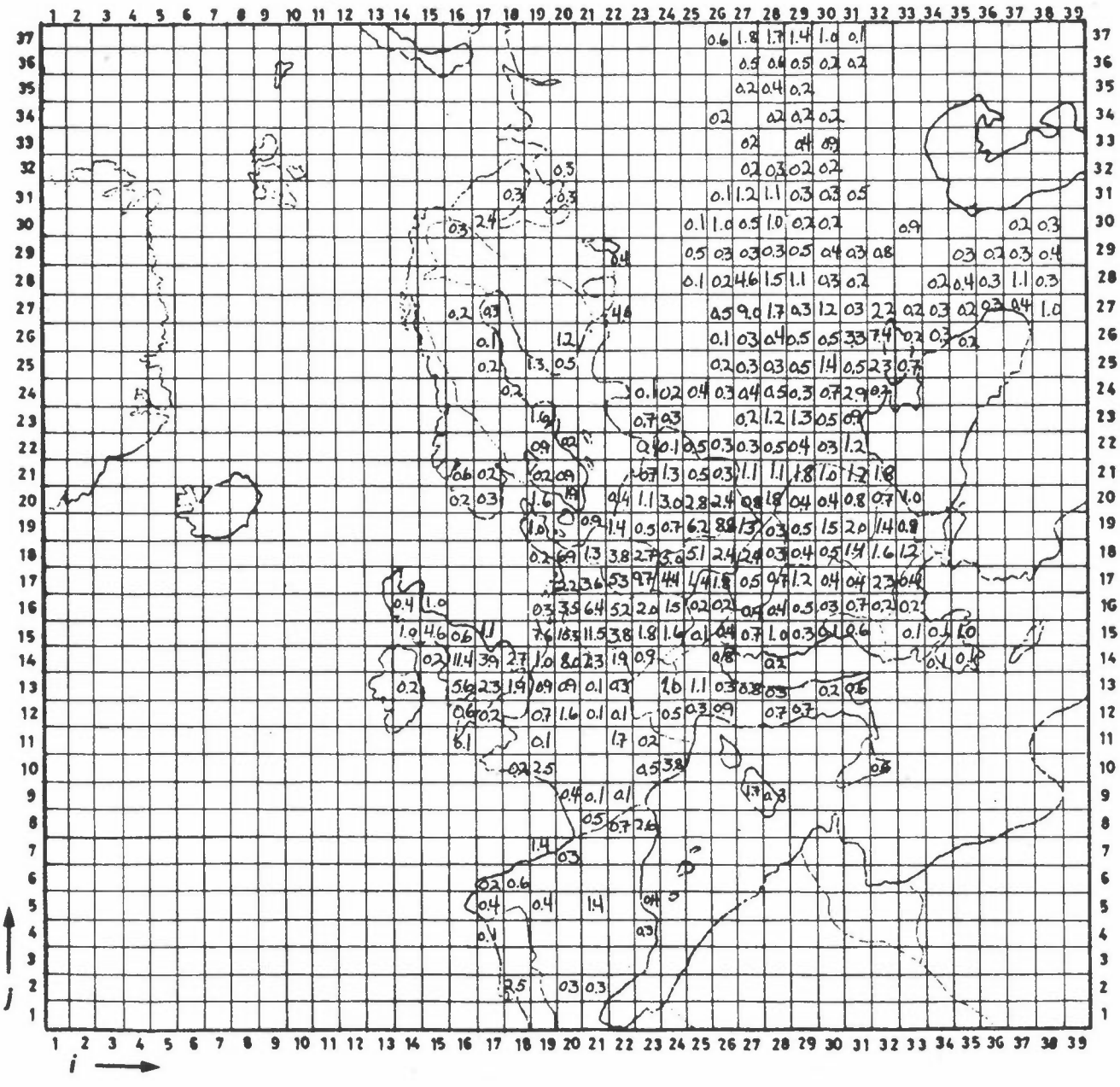

Figure 3: Spatial distribution of the Hg emissions in Europe in 1982 within the EMEP grid of 150 km x 150 km.

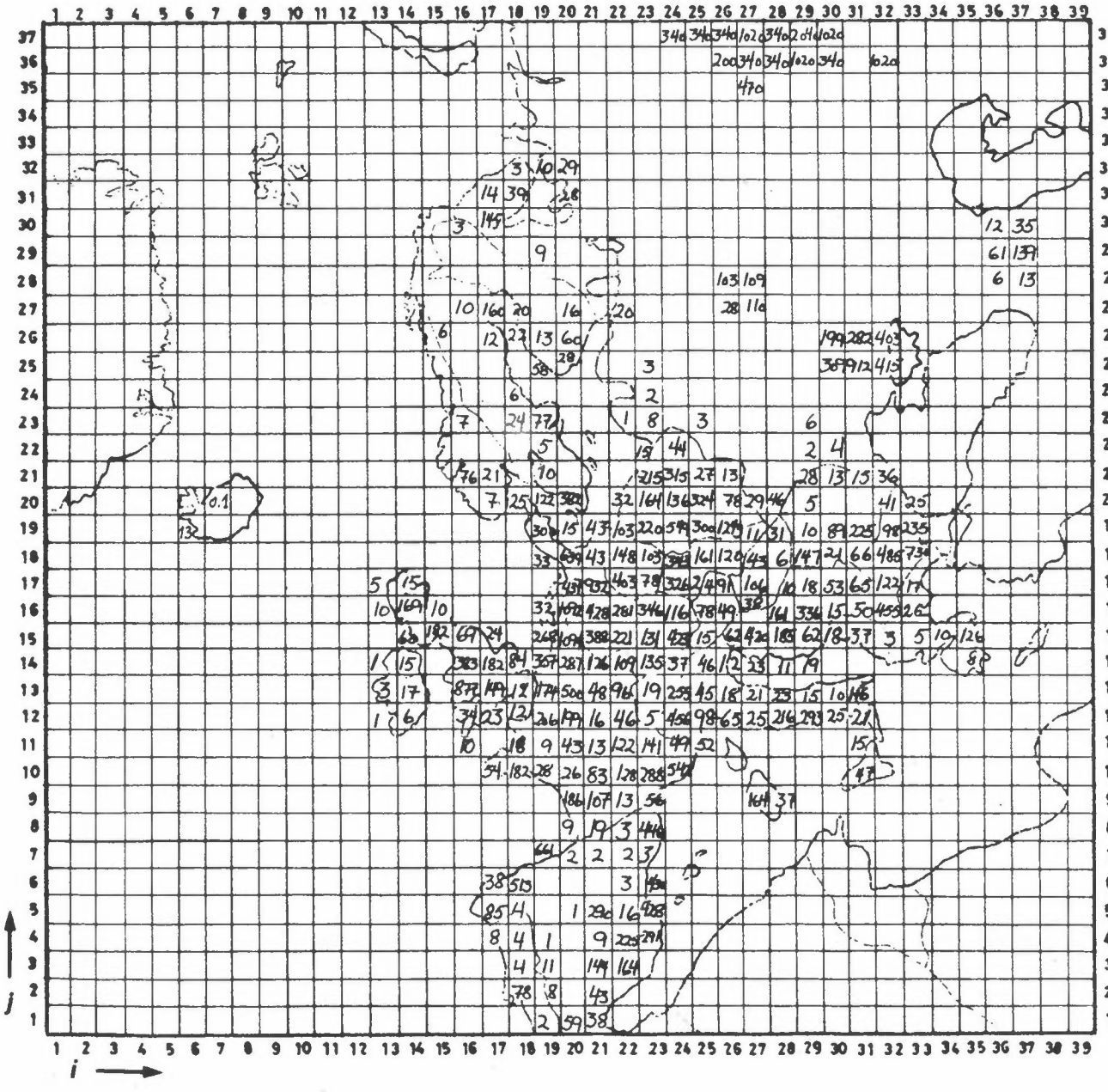

Figure 4: Spatial distribution of the Zn emissions in Europe in 1982 within the EMEP grid of 150 km x 150 km.

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TITLE
ABSTRACT (max. 300 characters, 7 lines) Atmospheric emissions of arsenic (As), cadmium (Cd), mercury (Hg) and zinc (Zn) from athropogenic sources in Europe are presented for 1982. Non-ferrous metal industry is the major emitter of As, Cd, Zn, while Hg is mainly emitted from the combustion of coal. Spatial distributions of these emissions show that the major source regions are in Poland, Czechoslovakia, German Democratic Republic, the Soviet Union, Federal Republic of Germany, France, Spain and Italy.

* Kategorier: Åpen - kan bestilles fra NILU A
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