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ATMOSPHERIC LEAD EMISSIONS IN EUROPE IN 1982

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SUMMARY

Atmospheric emissions of lead (Pb) from various sources in the European countries are presented for 1982. Emission estimates are based on emission factors and statistical information on the consumption of fossil fuels and the production of industrial goods. A total emission of ca. 90 000 t Pb was estimated, with 76% contribution from combustion and marketing of gasoline. Primary non-ferrous metal production in smelters accounted for 14.5%, iron and steel manufacturing 4%, fossil fuel combustion in electric power plants, and in industrial, residential and commercial boilers 3%, and the rest was ascribed to emissions from cement production, fuel-wood combustion and waste-related sources. One third of the European emissions of atmospheric Pb were released from sources in the Soviet Union, almost the same amount was emitted from the three West European countries: United Kingdom (U.K.), France and Italy, and the last third of the Pb releases in Europe are accounted for other countries. The spatial distribution of Pb emissions is shown in the EMEP grid of 150 km x 150 km.

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ATMOSPHERIC LEAD EMISSIONS IN EUROPE IN 1982

1 INTRODUCTION

This report presents the emissions of lead (Pb) from various anthropogenic sources in Europe in 1982. The estimates are based on emission factors and statistical information collected by Pacyna (1987a).

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

The estimates are given in Tables 1-8 and short comments follow each of the tables. The tables show that approximately one third of the European emissions of atmospheric lead are released from sources in the Soviet Union, almost the same amount is emitted from the three West European countries: U.K., France and Italy, and the last third of the Pb releases in Europe are accounted for 23 other countries. Turkey was not included in this survey.

Gasoline combustion is by far the largest source for the Pb emissions in Europe. In 1982, this source contributed approximately 76% to the total emissions. Primary non-ferrous metal production (smelters) accounted for 14.5%, iron and steel manufacturing 4%, fossil fuel combustion in electric power plants, and in industrial, residential and commercial boilers 3% and the rest (2.5%) was ascribed to emissions from cement production, fuel-wood combustion and waste-related sources. This last source is certainly underestimated due to lack of reliable information. Lead is also emitted from a number of other minor sources, including brass and bronze foundries, metal manufacturing plants, ferro-ally production, leaded alkyl manufacture, production of leaded glass, lead oxides and pigments, storage of batteries

and tar sands operations. These emissions are believed to be insignificant (below 5% of total emission of lead) as confirmed by Hutton (1982) and recently by Jaques (1987).

This work can be compared with the 1978/79 emission survey (Pacyna, 1983). The 1982 estimates, are lower by 27% than those for 1978/79. The major reasons for this difference are following: 1) Production/consumption statistics have changed, 2) Turkey is not included in the 1982 survey, 3) Only the European part of the Soviet Union is considered in the 1982 survey, and 4) Emission factors have changed. The last reason is the most important. Recently, more information has become available on the production technology employed in various industries in Europe. This resulted in changes of emission factors for source categories, such as non-ferrous metal production and iron and steel manufacturing, and consequently in changes of emission estimates. The largest changes were obtained for FRG, Belgium, Finland, Poland, Romania, Sweden and Switzerland. Details are presented after estimates for each source category.

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

U.K.	: 8614 t/y (this work) and 7590 (Hutton and Symon, 1986)
FRG	: 5562 t/y (this work) and 6500 (Nürnberg et al. 1983)
Sweden	: 1053 t/y (this work) and 950 (Naturvårdsverket, 1987-data for 1985)
Finland	: 1122 t/y (this work) and 1055 (Mukherjee, 1986)

It should be noted, however, that there are some differences between the above emission estimates for certain source categories, mainly for iron and steel manufacturing and non-ferrous metal production.

Finally, the Pb emission estimates are spatially distributed in the EMEP grid of 150 km x 150 km (Figure 1).

3 REFERENCES

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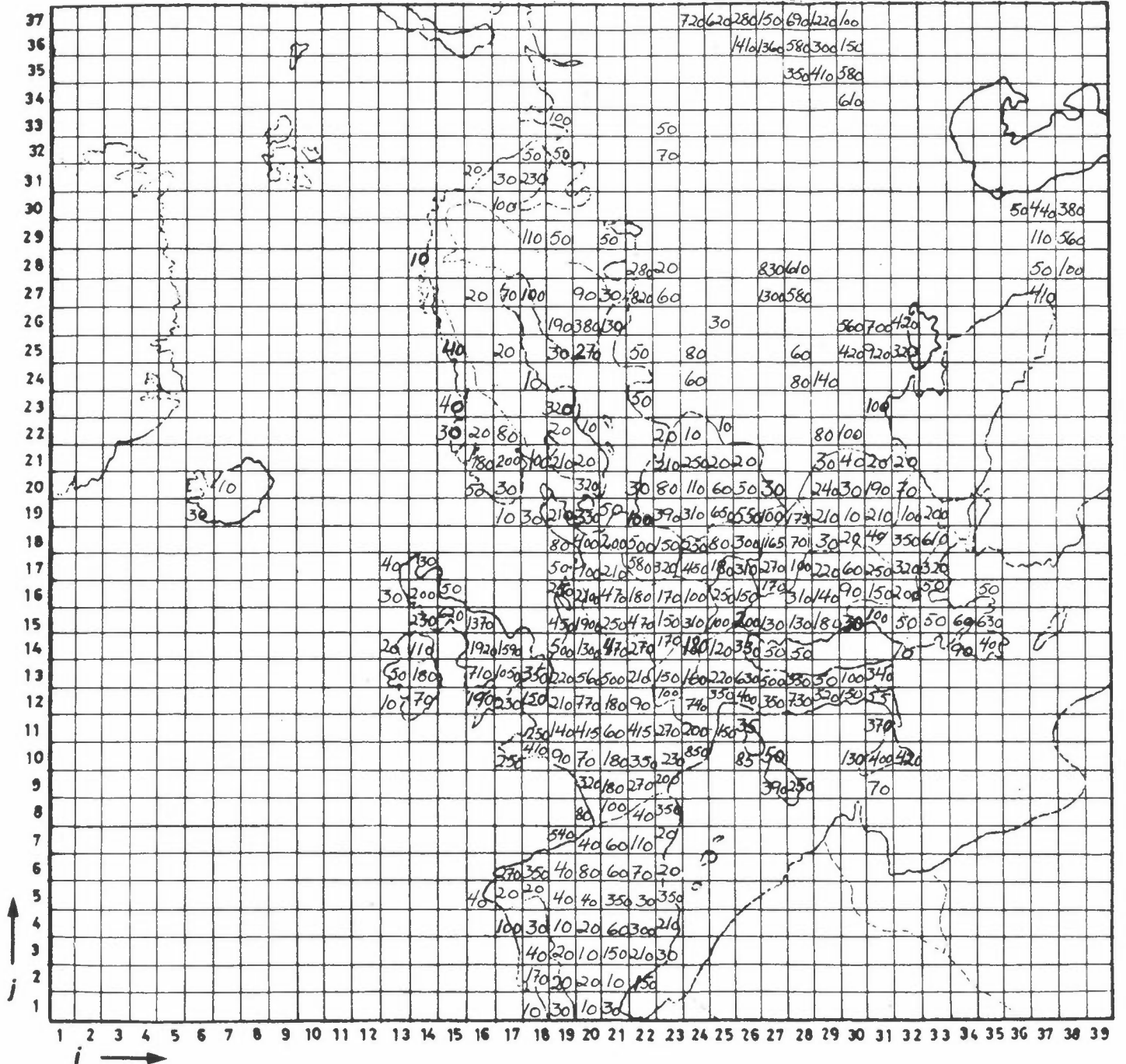


Fig. 1: Spatial distribution of the Pb emission in Europe (in t/y) within the EMEP grid of 150 km x 150 km.

Table 1: Lead emissions from gasoline combustion and marketing in Europe in 1982.

COUNTRY	GASOLINE COMBUSTION* ¹		Marketing t/y	TOTAL t/y
	Pb additives g/l	Emission t/y		
Albania	0.40	100	1	101
Austria	0.40	960	5	965
Belgium	0.40	1070	6	1076
Bulgaria	0.40	720	4	724
Czechoslovakia	0.40	680	4	684
Denmark	0.40	580	3	583
Finland	0.40	650	3	653
France	0.40	7220	38	7258
FRG	0.15	3420	18	3438
GDR	0.40	1260	7	1267
Greece	0.84	1300	7	1307
Hungary	0.40	500	3	503
Iceland	0.40	39	v.l.	39
Ireland	0.40	390	2	392
Italy	0.635	7570	31	7601
Luxemburg	0.40	125	1	126
Netherlands	0.40	1690	9	1699
Norway	0.34* ²	500	3	503
Poland	0.40	1200	6	1206
Portugal	0.40	340	2	342
Romania	0.40	610	3	613
Spain	0.60	2950	16	2966
Sweden	0.15	520	3	523
Switzerland	0.15	430	2	432
UK	0.40	7470	40	7510
USSR* ³	0.40	27800	147	27947
USSR-Europe	0.40	24740	131	24871
Yugoslavia	0.40	950	5	955
Total Europe		67984	353	68337

Notes

v.l. = very low.

*1 The following assumptions are made:

1 The density of gasoline consumed is 0.74 kg/l.

2 Approximately 75% of the lead contained in the gasoline burned is emitted directly to the atmosphere.

*2 $0.75 \times 0.4 \text{ g/l} + 0.25 \times 0.15$.

*3 About 89% of gasoline in the Soviet Union is used in the European part of the country, based on the information on

a) tonnes x km and b) passenger x km.

Comments

Comparing the 1982 data and the 1979/1980 data for the Pb emissions from gasoline combustion, there has been a decrease of 8.5%. The reasons are following:

- Updated information on the use of Pb additives in the following countries: Belgium, Norway, Sweden, Switzerland, Italy, Finland.
- Only the European part of the Soviet Union has been considered.

In addition to the inorganic emissions of Pb from the combustion of leaded gasoline, organic lead emissions occur during the handling of gasoline. These emissions occur as losses of lead alkyl vapours when transferring gasoline at the refinery, transfer terminal, bulk station, and finally the service station. Based on extended survey in Canada (Jaques, 1985), a factor of 1.84 g/1000 liters is estimated for gasoline with 0.46 g Pb/l. This means that the losses of Pb were 0.4% of total lead added to gasoline.

Table 2: Lead emissions from non-ferrous metal production in Europe in 1982 (in t/y).

COUNTRY	Mining ^{*1}	Primary ^{*2} copper-nickel	Secondary ^{*3} copper	Primary ^{*4} zinc	Primary ^{*6} lead	Secondary ^{*7} lead	TOTAL
Albania		23.4					23
Austria	5.1	17.6	4.4	35.7	10.2		73
Belgium			67.2	446	299		812
Bulgaria	86.5	121.0	8.0	167	354		737
Czechoslovakia	2.4	59.1	3.4	4.4	63.3		133
Denmark						3.2	3
Finland	1.7	129.0	6.4	266			403
France	5.4		6.1	451	433	15.3	911
FRG	21.4	412	52.7	435	332	51.0	1304
GDR		33.2	6.8	31.5	150		222
Greece	17.2				10		27
Hungary		5.1	3.1		2.4		10
Iceland							-
Ireland	33.0						33
Italy	7.9		2.6	293	109	19.5	432
Luxemburg							-
Netherlands				344	32.4		376
Norway	3.3	47.6	3.2	146			200
Poland	41.2	717.0	46.6	306	236		1347
Portugal		8.0	0.6				8
Romania	24.6	78.0			137.0		240
Spain		263.0	23.0	336.3	298.5	6.4	927
Sweden	77.1	175.0	8.4		102		363
Switzerland							-
UK	3.0		18.0	147 ^{*5}	393 ^{*5}	35.0	596
USSR-Europe	391.3	1570.0	129.5	460	436	14.7	3002
Yugoslavia	103.0	333.0	17.0	160.0	244		857
Total Europe	824.1	3992	407.0	4029	3642	145	13039

Notes

- *1 Emission factor used: 910 g/t Pb processed (Pacyna, 1983).
*2 Emission factor used: 1950 g/tonne of Cu-Ni produced based on recent review by Nriagu and Pacyna (1987).
*3 Emission factor used: 134 g/tonne of Cu-Ni (Pacyna, 1983).
*4 Emission factor used: 1850 g/t of Zn-Cd produced based on recent review by Nriagu and Pacyna (1987).
*5 Assuming 30% of the production in the European part of the Soviet Union.
*6 Emission factor used: 3000 g/t of Pb produced after Nriagu and Pacyna (1987).
*7 Emission factor used: 200 g/t (based on data from Canada - Jaques, 1985).

CommentsMining.

Not much difference between 1978/1979 and 1982. If so, differences are due to the production changes.

Primary copper-nickel production.

Significant changes, by a factor of 2.5 (lower in 1982). The following reasons can be given:

A) Accurate data on a part of Pb produced in smelters became now available.

B) Lower emission factor as reviewed by Nriagu and Pacyna (1987).

C) For the Eastern Europe the data 1978/1979 include secondary production.

Secondary copper production

Major changes, however, unimportant for total emissions. Differences due to the production data changes.

Primary zinc production.

The 1978/1979 data higher by a factor of 2 due to:

a) lower emission factor for 1982

b) the Eastern European data in 1982 included both primary and secondary production

c) changes in production data.

Primary lead production.

The 1982 data lower by a factor of 3 due to changes in emission factors.

Table 3: Lead emissions from iron and steel production in Europe in 1982 (in t/y).

COUNTRY	Iron ^{*1} sintering	Basic oxygen ^{*2} furnace	Electric arc ^{*3} furnace	Open ^{*4} hearth furnace	TOTAL
Albania					
Austria	34.7	6.1	4.5		45.3
Belgium	87.4	14.7	9.0		111.1
Bulgaria	17.9	2.2	10.1	0.8	31.0
Czechoslovakia	101.9	9.6	33.6	16.2	161.3
Denmark			11.8		11.8
Finland	21.3	3.2	4.5		29.0
France	151.2	23.7	40.3		215.2
FRG	294.5	46.2	78.4		419.1
GDR	19.0	1.6	24.6	10.3	55.5
Greece		0.8	5.6		6.4
Hungary	23.5	2.1	4.5	5.4	35.5
Iceland					
Ireland			0.7		0.7
Italy	126.6	18.1	142.2		286.9
Luxemburg	29.1	5.6			34.7
Netherlands	40.3	6.7	2.2		49.2
Norway	12.3	0.6	3.4		16.3
Poland	81.8	10.1	24.6	17.1	133.6
Portugal	2.2	0.3	3.4		5.9
Romania	89.6	10.2	30.2	10.8	140.8
Spain	67.2	8.5	88.5		164.2
Sweden	20.2	3.0	22.4		45.6
Switzerland		1.1	2.2		3.3
UK	93.0	14.9	49.3		157.2
USSR-Europe	1195.0	74.4	184.8	226.5	1680.7
Yugoslavia	42.6	2.4	11.2	3.5	59.7
Total Europe	2551.3	266.1	792.0	290.6	3900

Notes

Emission factors used:

*1 11.2 g/t sinter

*2 1.6 g/t steel

*3 11.2 g/t steel

*4 2.7 g/t steel

Comments

The 1978/79 emission data were higher than the 1982 emission data by a factor of 4 due to changes in emission factors. More information has become available on technology employed in various countries so the emission factors have changed. In addition, only the European part of the Soviet Union was included in the 1982 survey. Turkey was not included. There were also some changes of production statistics.

Table 4: Lead emissions from fossil fuel combustion in Europe in 1982 (in t/y).

COUNTRY	Power plants* ¹			Industrial* ² commercial residential burners	TOTAL
	Hard coal	Lignite	Oil		
Albania	-	0.3	-	3.3	3.6
Austria	0.1	1.2	5.9	17.9	25.1
Belgium	12.5	-	10.3	52.0	74.8
Bulgaria	-	13.4	5.5	52.1	71.0
Czechoslovakia	3.2	35.1	3.4	83.4	125.1
Denmark	5.3	-	2.4	13.0	20.7
Finland	2.1	-	2.9	16.3	21.3
France	14.6	1.1	13.8	97.2	126.7
FRG	22.7	32.6	10.0	116.4	181.7
GDR	-	80.3	-	101.4	181.7
Greece	-	5.2	4.9	12.3	22.4
Hungary	0.8	9.2	2.5	16.4	28.9
Iceland	-	-	v.l.	v.l.	v.l.
Ireland	0.1	1.5	0.7	6.2	8.5
Italy	5.2	0.8	54.4	86.2	146.6
Luxemburg	v.l.	-	0.1	1.5	1.6
Netherlands	3.1	-	11.7	11.5	26.3
Norway	0.1	-	-	v.l.	0.1
Poland	68.5	28.6	-	179.9	277.0
Portugal	0.3	-	3.9	7.5	11.7
Romania	-	15.7	26.5	78.2	120.4
Spain	7.0	12.8	16.0	50.5	86.3
Sweden	v.l.	-	4.5	25.8	30.3
Switzerland	v.l.	-	0.2	4.3	4.5
UK	53.4	-	8.4	122.3	184.1
USSR-Europe* ³	237.9	137.3	269.3	422.6	1067.1
Yugoslavia	-	31.7	-	27.8	59.5
Total Europe	436.9	406.8	457.3	1606.0	2907.0

Notes

v.l. very low.

*1 Emission factors used to calculate the above emissions were the same as in the previous emission survey (Pacyna, 1983).

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

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

Table 5: Lead emissions from cement production in Europe in 1982.

COUNTRY	EMISSION ^{*1} t/y
Albania	2.0
Austria	9.0
Belgium	11.4
Bulgaria	10.1
Czechoslovakia	18.6
Denmark	3.2
Finland	3.4
France	47.0
FRG	54.1
GDR	21.0
Greece	23.2
Hungary	7.9
Iceland	0.2
Ireland	2.9
Italy	72.4
Luxemburg	0.6
Netherlands	5.6
Norway	3.1
Poland	28.9
Portugal	10.7
Romania	25.1
Spain	53.3
Sweden	4.2
Switzerland	7.4
UK	23.3
USSR ^{*2}	148.4
Yugoslavia	15.7
Total Europe	612.7

Notes

*1 Emission factor used: 1.8 g/t cement produced - the same as in the 1978/79 survey (Pacyna, 1983).

*2 It was assumed that two third of the total production of cement in the USSR was produced in the European part of the country.

Table 6: Lead emissions from fuel-wood combustion in Europe in 1982.

COUNTRY	Emission ^{*1} t/y
Albania	6.2
Austria	5.5
Belgium	2.2
Bulgaria	6.6
Czechoslovakia	6.7
Denmark	1.4
Finland	12.9
France	40.0
FRG	16.0
GDR	2.9
Greece	7.6
Hungary	11.0
Iceland	
Ireland	0.2
Italy	17.2
Luxemburg	0.1
Netherlands	0.4
Norway	3.1
Poland	10.2
Portugal	1.6
Romania	17.4
Spain	5.4
Sweden	66.5
Switzerland	3.7
UK	0.6
USSR ^{*2}	159.1
Yugoslavia	15.1
Total Europe	419.6

Notes

*1 Emission factor used: 7 g/tonne of wood - the same as in the 1978/79 emission survey (Pacyna, 1983).
The wood density was assumed 546 kg/m³.

*2 A half of the total wood combustion in the European part of the country.

Table 7: Lead emissions from waste-related sources in Europe - based on national data (in t/y).

COUNTRY	Municipal waste incin.	Sewage sludge incin.	Total
Albania			
Austria			
Belgium ^{*1}			9.5
Bulgaria			
Czechoslovakia			
Denmark ^{*1}			30.0
Finland			
France ^{*1}			86.1
FRG ^{*2}	120	28.8	148.8
GDR			
Greece			
Hungary			
Iceland			
Ireland			
Italy ^{*1}			45.7
Luxemburg ^{*1}			1.8
Netherlands ^{*1}			48.9
Norway ^{*4}	1.8		1.8
Poland			
Portugal			
Romania			
Spain			
Sweden ^{*5}	20.0		20.0
Switzerland			
UK ^{*3}	142	1.2	143.2
USSR			
Yugoslavia			
Total Europe	283.8	30	535.8

Notes

- *1 The emission data were obtained from the 1978/79 survey (Pacyna, 1983).
 *2 Based on Vogg et al. (1986).
 *3 Based on Hutton (1982).
 *4 Based on Miljøverndepartementet (1984).
 *5 Based on Naturvårdsverket (1982).

Comments

The data presented in Table 7 are very incomplete. Still there is very little information available on the Pb emissions from waste-related sources. This problem is recognized as very important but very scanty information exists even on the amount of incinerated wastes, and even less on the heavy metal concentrations in the emitted gases and particles.

Table 8: Total lead emissions in the European countries in 1982
(in t/y).

COUNTRY	Gasoline combustion & marketing	Non-ferrous metal production	Iron and steel production	Fossil fuel combustion	Cement production	Fuel-wood combustion	Waste- related sources	Total
Albania	101	23	-	4	2	6		136
Austria	965	73	45	25	9	6		1123
Belgium	1076	812	111	75	11	2	10	2097
Bulgaria	724	737	31	71	10	7		1580
Czechoslovakia	684	133	161	125	19	7		1129
Denmark	583	3	12	21	3	1	30	653
Finland	653	403	29	21	3	13		1122
France	7258	911	215	127	47	40	86	8684
FRG	3438	1304	419	182	54	16	149	5562
GDR	1267	222	56	182	21	3		1751
Greece	1307	27	6	22	23	8		1393
Hungary	503	10	35	29	8	11		596
Iceland	39	-	-	-	-	-		39
Ireland	392	33	1	9	3	-		438
Italy	7601	432	287	147	74	17	46	8604
Luxemburg	126	-	35	2	1	-	2	166
Netherlands	1699	376	49	26	6	-	49	2205
Norway	503	200	16	-	3	3	2	727
Poland	1206	1347	134	277	29	10		3003
Portugal	342	8	6	12	11	2		381
Romania	613	240	141	120	25	17		1156
Spain	2966	927	164	86	53	5		4201
Sweden	523	363	46	30	4	67	20	1053
Switzerland	432	-	3	4	7	4		450
UK	7510	596	157	184	23	1	143	8614
USSR-Europe	24871	3002	1681	1067	148	159		30928
Yugoslavia	955	857	60	59	16	15		1962
Total Europe	68337	13039	3900	2907	613	420	537	89753

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* Kategorier: Åpen - kan bestilles fra NILU A
 Må bestilles gjennom oppdragsgiver B
 Kan ikke utleveres C