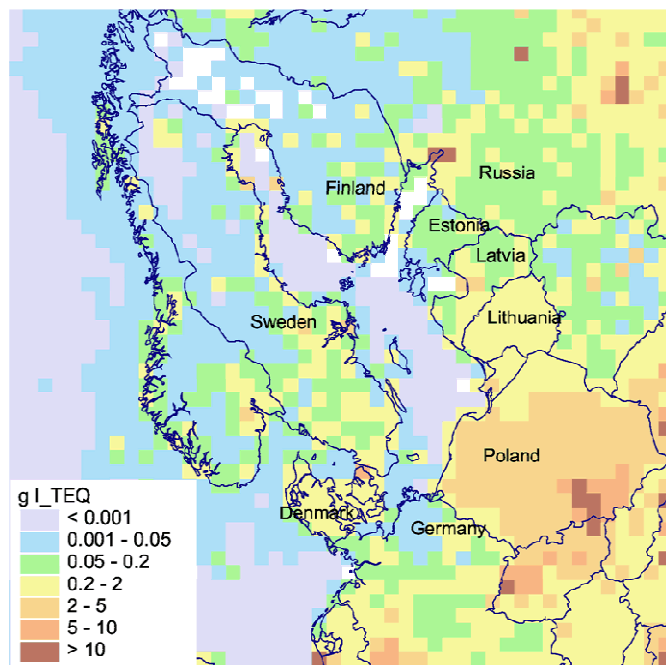


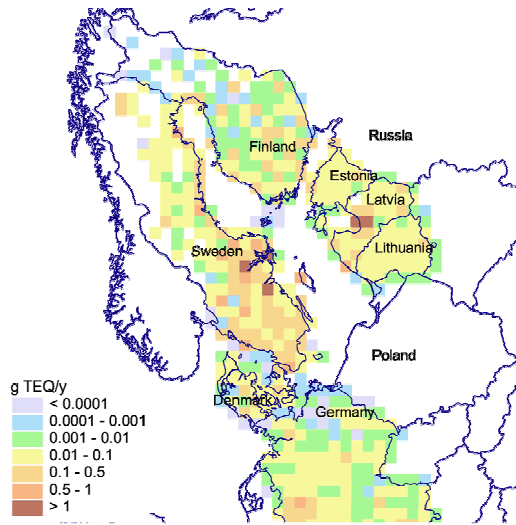
## 7. Atmospheric Supply of PCDD/Fs to the Baltic Sea in 2006

In this chapter the results of model evaluation of dioxins and furans (PCDD/Fs) atmospheric input to the Baltic Sea and its sub-basins for 2006 is presented. Modelling of PCDD/F atmospheric transport and depositions was carried out using MSC-E Eulerian Persistent Organic Pollutant transport model MSCE-POP (*Gusev et al., 2005*). Latest available official information on PCDD/F emission from HELCOM countries and other European countries was used in computations. Based on these data levels of annual and monthly PCDD/F depositions to the Baltic Sea region have been obtained and contributions of HELCOM countries emission sources to the depositions over the Baltic Sea are estimated.

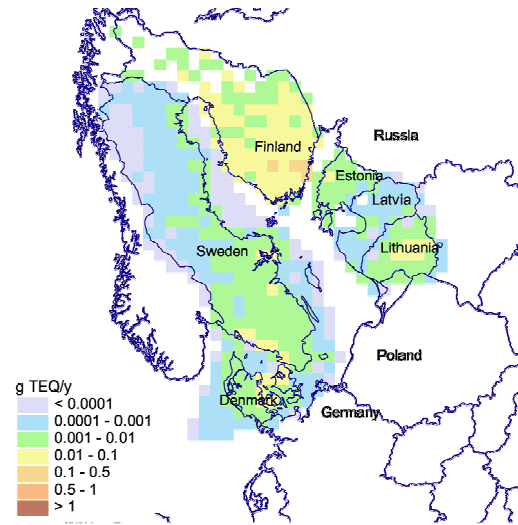
### 7.1 PCDD/Fs emissions



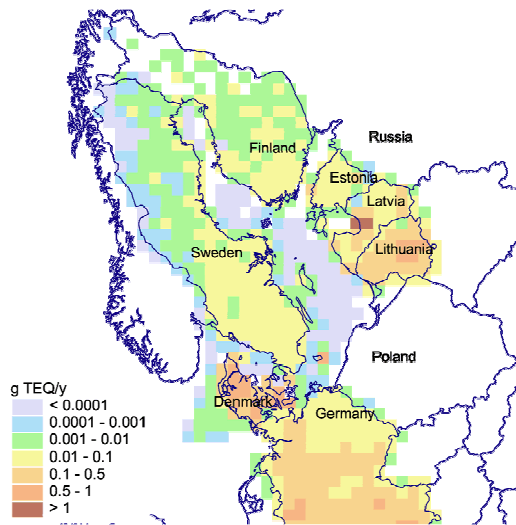
**Figure 7.1.** Annual total anthropogenic emissions of PCDD/F in the Baltic Sea region for 2006, g TEQ/year.



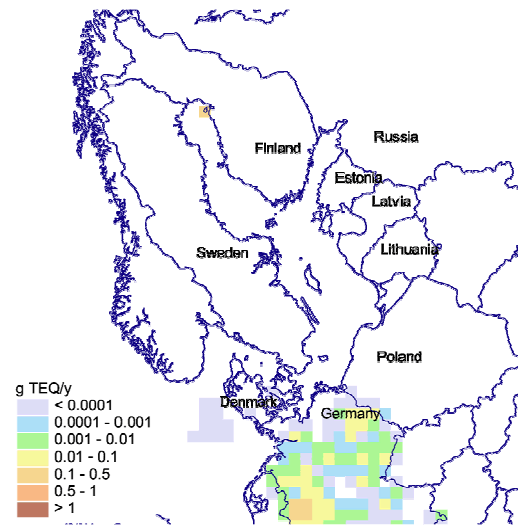
**Figure 7.2.** Annual PCDD/F emission of HELCOM countries from Combustion in Power Plants and Industry sector for 2006, g TEQ/y.



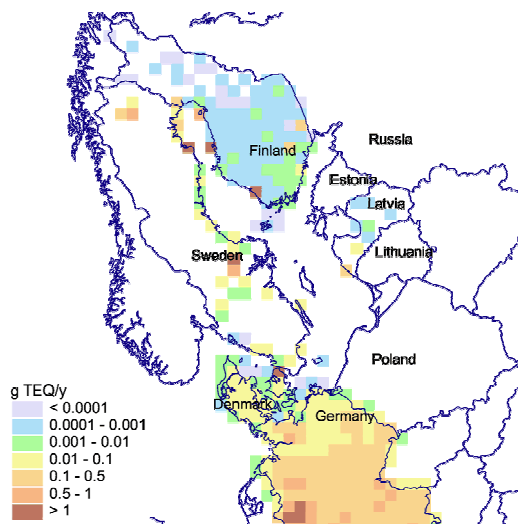
**Figure 7.3.** Annual PCDD/F emission of HELCOM countries from Transport sources below 1000 m sector for 2006, g TEQ/y.



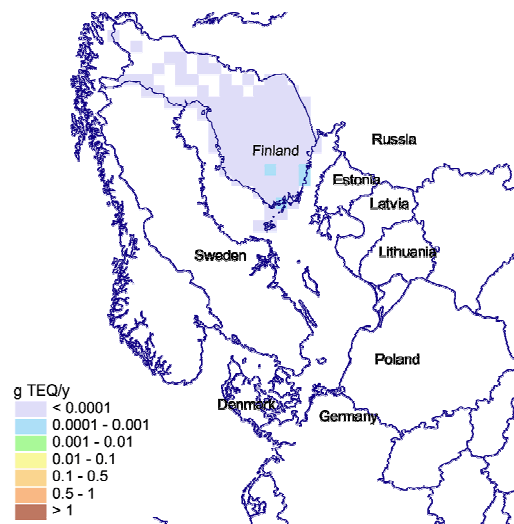
**Figure 7.4.** Annual PCDD/F emission of HELCOM countries from Commercial, Residential and Other Stationary Combustion sector for 2006, g TEQ/y.



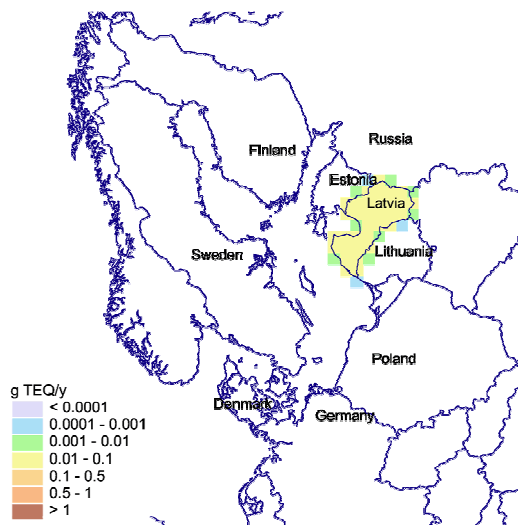
**Figure 7.5.** Annual PCDD/F emission of HELCOM countries from Fugitive Emissions From Fuels sector for 2006, g TEQ/y.



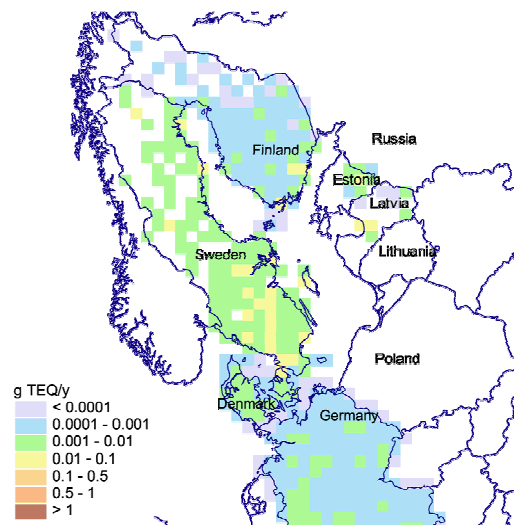
**Figure 7.6.** Annual PCDD/F emission of HELCOM countries from Industrial Processes sector for 2006, g TEQ/y.



**Figure 7.7.** Annual PCDD/F emission of HELCOM countries from Solvent and Other Product Use sector for 2006, g TEQ/y.



**Figure 7.8.** Annual PCDD/F emission of HELCOM countries from Agriculture sector for 2006, g TEQ/y.

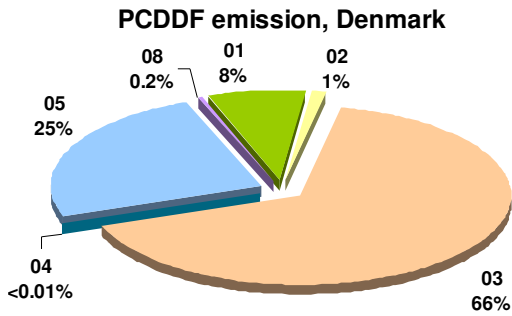


**Figure 7.9.** Annual PCDD/F emission of HELCOM countries from Waste sector for 2006, g TEQ/y.

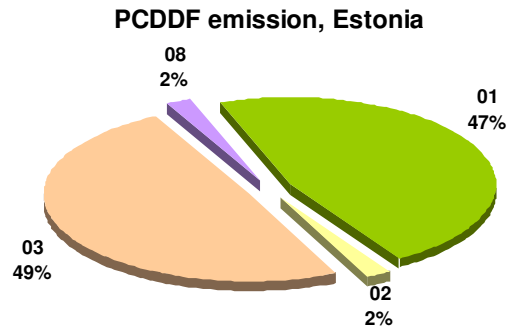
**Table 7.1.** Annual total PCDD/F anthropogenic emissions of HELCOM countries from different sectors for 2006, in g TEQ/year

NFR emission sector	Sector name	DK	EE	FI	DE	LV	LT	PL	RU	SE
1	Combustion in Power Plants and Industry	1.9	1.2	5.1	6.9	5.8	1.4	46.7	777.5	27.0
2	Transport	0.3	0.05	2.7	3.6	0.02	0.2	0.7		0.6
3	Commercial, Residential and Other Stationary Combustion	16.5	1.3	1.1	23.8	6.4	9.5	201.4		2.9
4	Fugitive Emissions From Fuels	1.8E-04	NA	0.2	1.7	NO		2.9		
5	Industrial Processes	6.1		5.0	48.4	0.3		14.8		5.9
6	Solvent and Other Product Use	NA	NA	0.002	NA			NA		NA
7	Agriculture				NA	1.2		0.5		
8	Waste	0.04	0.05	0.2	0.1	0.1		182.2		1.1
9	Other				NA					
<b>Total</b>		<b>24.8</b>	<b>2.7</b>	<b>14.2</b>	<b>84.6</b>	<b>13.8</b>	<b>11.2</b>	<b>449.3</b>	<b>777.5</b>	<b>37.5</b>

NA – not available  
 NO – not observed



**Figure 7.10.** Percentage of annual total PCDD/F emission from different sectors in Denmark for 2006



**Figure 7.11.** Percentage of annual total PCDD/F emission from different sectors in Estonia for 2006

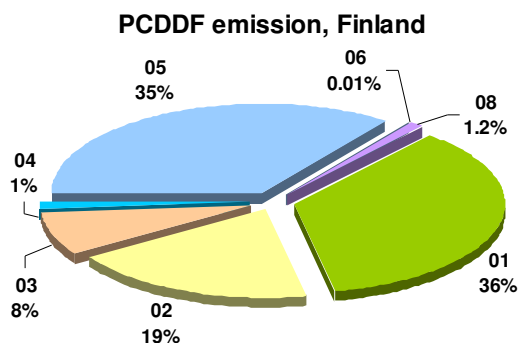


Figure 7.12. Percentage of annual total PCDD/F emission from different sectors in Finland for 2006

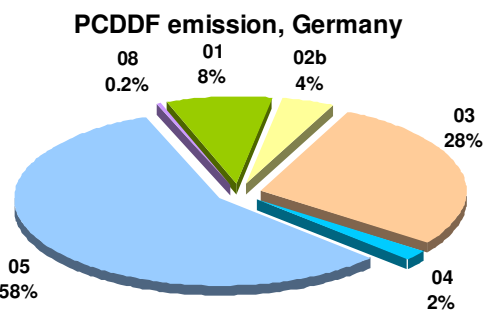


Figure 7.13. Percentage of annual total PCDD/F emission from different sectors in Germany for 2006

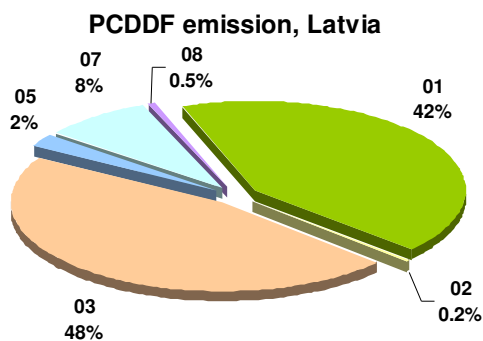


Figure 7.14. Percentage of annual total PCDD/F emission from different sectors in Latvia for 2006

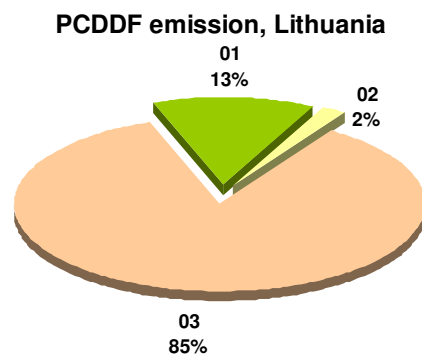


Figure 7.15. Percentage of annual total PCDD/F emission from different sectors in Lithuania for 2006

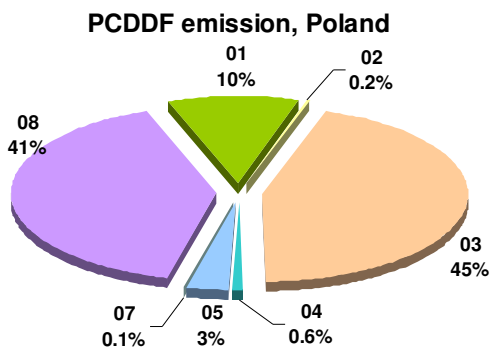


Figure 7.16. Percentage of annual total PCDD/F emission from different sectors in Poland for 2006

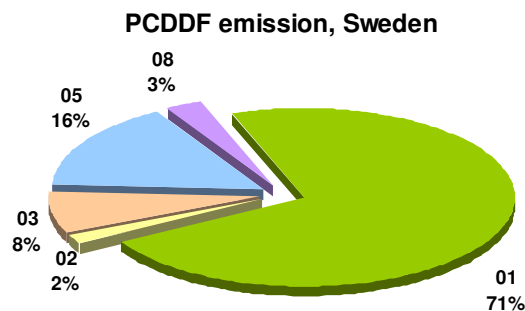
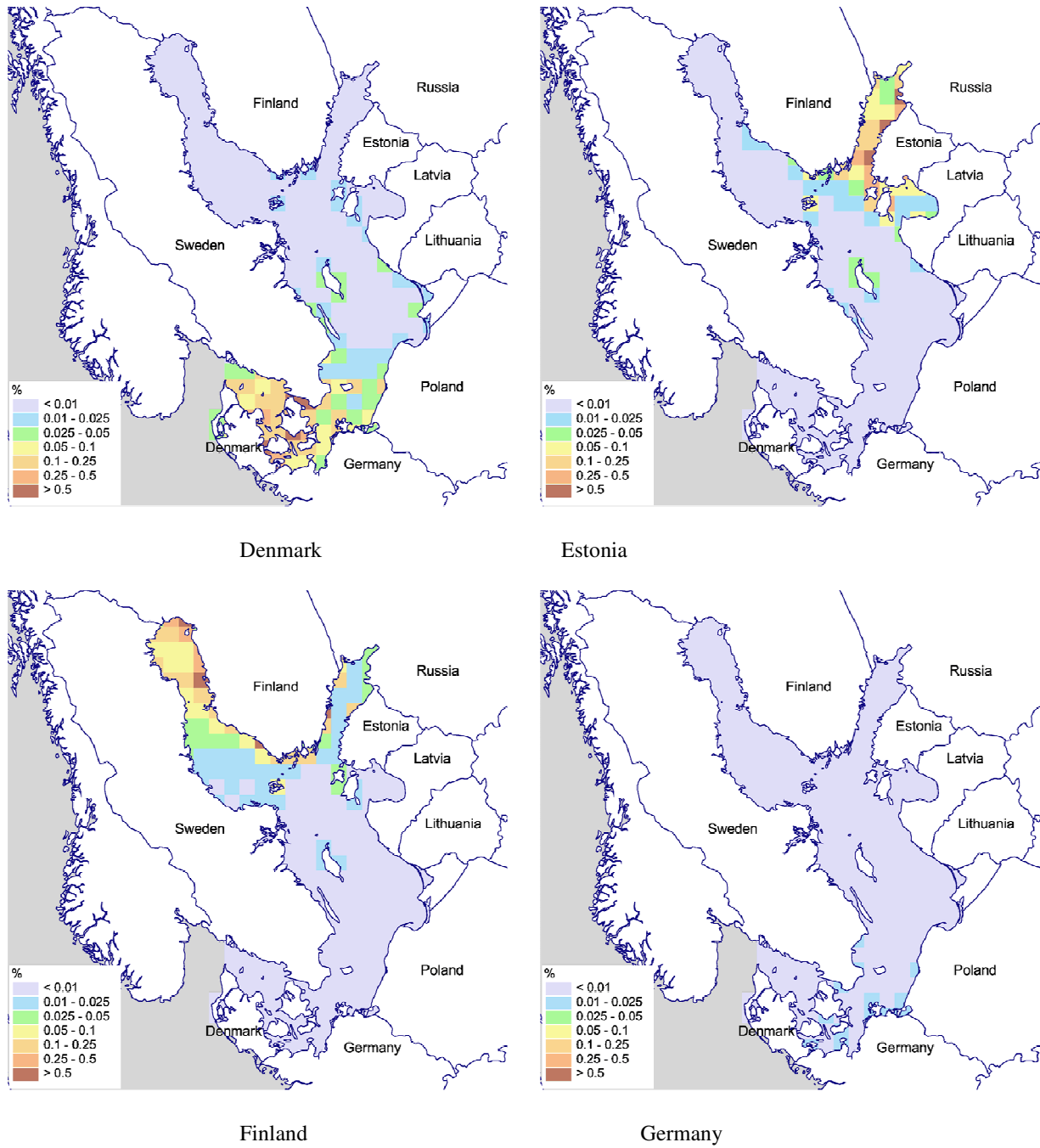
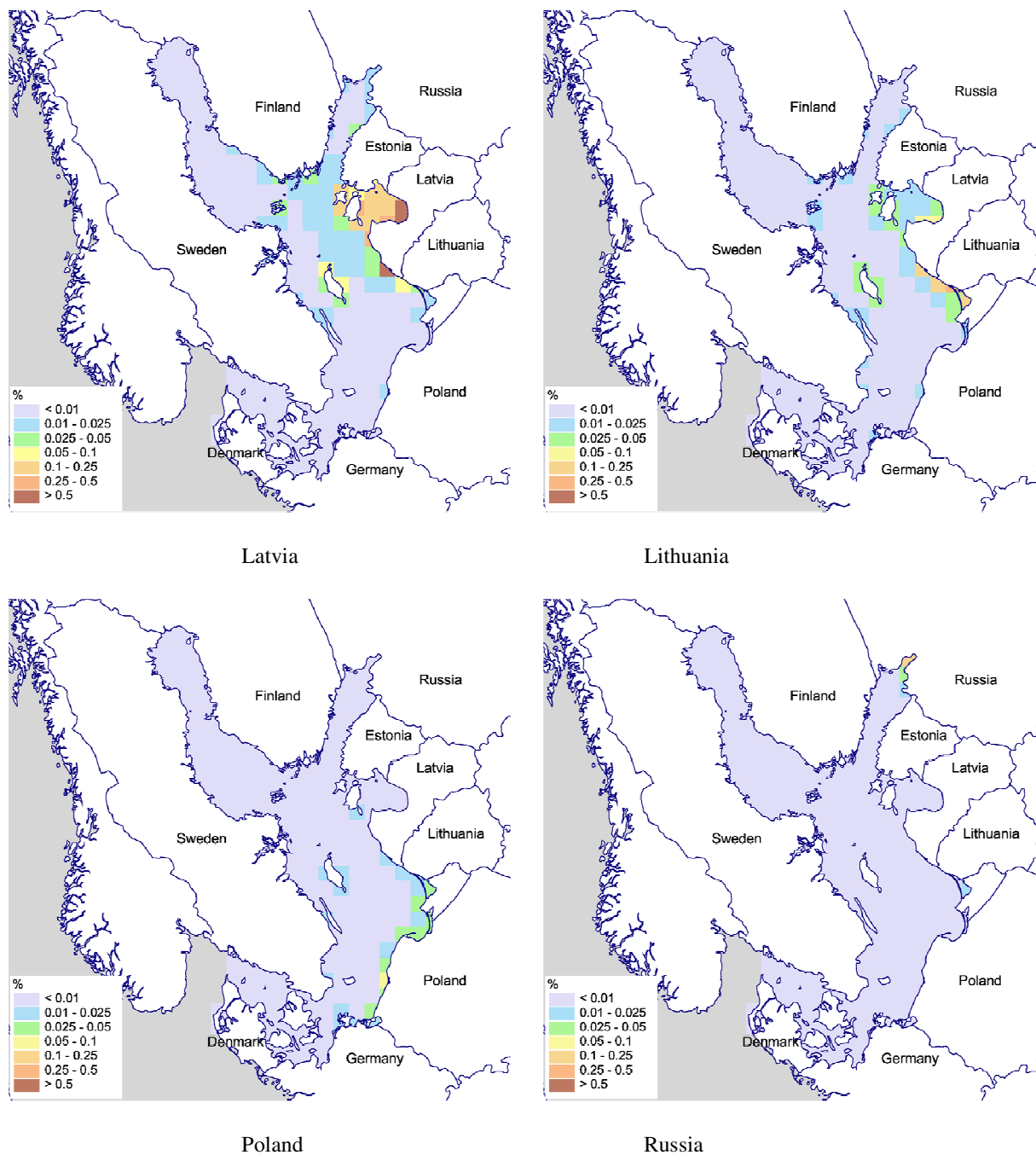


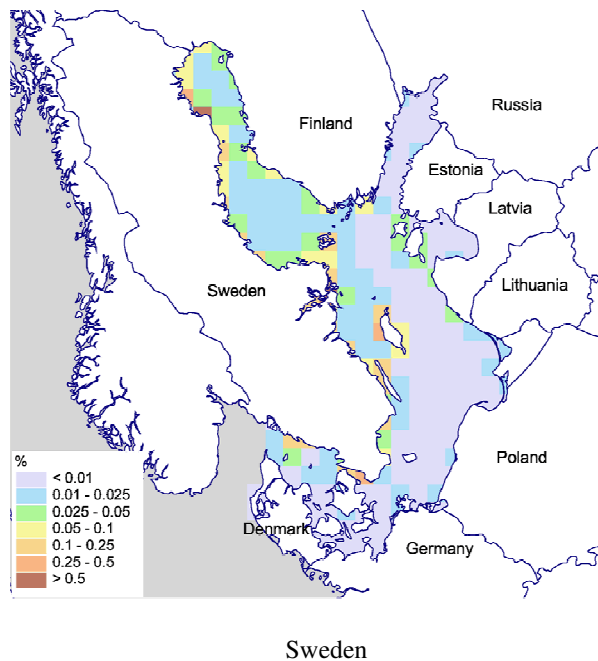
Figure 7.17. Percentage of annual total PCDD/F emission from different sectors in Sweden for 2006



**Figure 7.18.** Maps with the fractions (in %) of annual total anthropogenic PCDD/F emissions from HELCOM Parties deposited over the Baltic Sea in 2006 (percent per deposition over the 50x50 km grid cell).



**Figure 7.18. (cont.)** Maps with the fractions (in %) of annual total anthropogenic PCDD/F emissions from HELCOM Parties deposited over the Baltic Sea in 2006 (percent per deposition over the 50x50 km grid cell).



**Figure 7.18. (cont.)** Maps with the fractions (in %) of annual total anthropogenic PCDD/F emissions from HELCOM Parties deposited over the Baltic Sea in 2006 (percent per deposition over the 50x50 km grid cell).

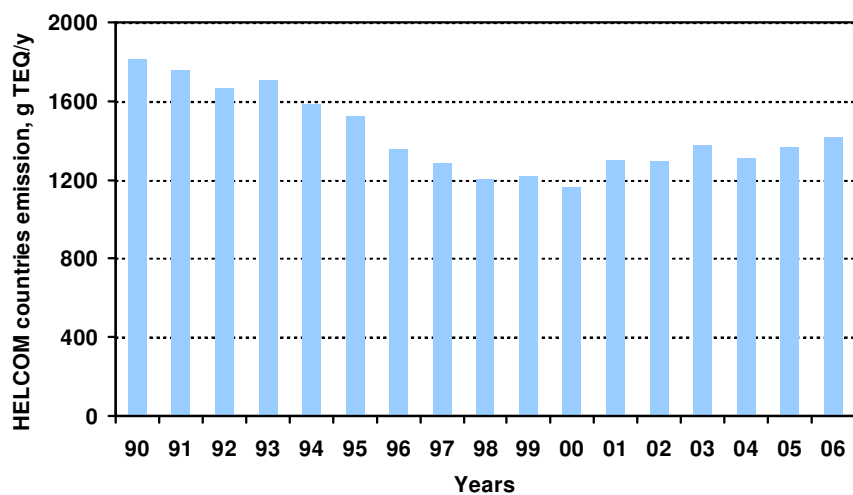


**Table 7.2.** Annual total anthropogenic emissions of PCDD/Fs of HELCOM countries and other EMEP countries in period 1990–2006, g TEQ/year (Unofficial emissions are shaded).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Denmark	67	64	59	54	51	49	47	44	37	31	32	30	27	29	24	26	25
Estonia	5.7	5.4	4.3	3.6	3.8	4.5	4.9	4.8	3.8	3.4	3.4	3.5	3.7	4.1	3.7	3.3	2.7
Finland	36	35	33	35	41	41	40	39	40	41	32	31	32	32	32	26	14
Germany	114	105	86	82	80	89	85	90	84	80	83	82	81	81	83	83	85
Latvia	7.1	7.6	7.3	8.4	9.0	10	11	12	11	12	10	11	11	12	13	13	14
Lithuania	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	6.0	5.0	4.3	13	12	12	11	11	11
Poland	529	535	517	592	520	515	484	440	381	381	333	447	433	482	387	416	449
Russia	991	947	901	878	825	769	637	614	606	625	631	643	655	686	716	747	778
Sweden	60	53	50	47	44	40	38	37	35	34	33	34	34	33	36	38	37
<b>HELCOM</b>	<b>1814</b>	<b>1758</b>	<b>1663</b>	<b>1705</b>	<b>1579</b>	<b>1523</b>	<b>1353</b>	<b>1285</b>	<b>1204</b>	<b>1213</b>	<b>1162</b>	<b>1294</b>	<b>1289</b>	<b>1372</b>	<b>1306</b>	<b>1364</b>	<b>1416</b>
Albania	43	43	43	43	43	43	43	43	43	43	43	43	44	44	44	44	44
Armenia	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47
Austria	160	135	76	67	56	58	60	59	56	54	52	54	43	43	43	45	44
Azerbaijan	98	98	98	98	98	98	98	98	98	98	98	99	100	101	102	102	103
Belarus	16	16	16	16	16	16	16	16	15	18	23	25	26	26	25	24	27
Belgium	569	563	529	496	489	402	352	378	271	140	124	88	59	62	65	59	55
Bosnia and Herzegovina	67	67	67	67	67	67	67	67	67	67	67	65	63	61	59	57	56
Bulgaria	554	535	515	495	476	456	341	310	288	245	233	201	219	255	239	230	247
Croatia	179	165	152	138	124	111	97	95	111	98	109	76	75	97	93	91	93
Cyprus	7.7	7.4	7.8	7.9	7.8	7.8	7.5	7.3	7.3	7.3	7.1	7.2	7.3	6.1	5.9	5.9	5.9
Czech Republic	1252	1220	1220	1140	1135	1135	922	830	767	643	744	620	177	114	187	179	175
France	1763	1814	1836	1894	1893	1695	1479	1043	939	611	520	385	358	237	299	216	127
Georgia	122	122	122	122	122	122	122	122	122	122	122	122	111	98	85	85	85
Greece	279	279	279	279	279	279	279	279	279	279	279	255	231	207	183	159	135
Hungary	172	148	104	103	100	95	90	84	74	77	74	76	75	74	74	92	92
Iceland	9.2	9.0	8.7	7.7	7.0	6.0	5.3	5.1	4.2	3.4	3.1	2.8	2.5	2.1	1.5	1.5	1.5
Ireland	27	27	27	27	27	27	27	27	27	27	27	27	27	26	27	26	26
Italy	473	495	476	451	441	460	419	426	413	388	369	293	283	282	290	294	302
Kazakhstan	40	40	40	40	40	40	40	40	40	40	40	40	41	41	41	42	42
Luxembourg	45	40	34	29	23	24	16	16	8.0	6.7	5.4	4.1	2.9	1.6	1.6	1.6	1.6
Malta	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9
Monaco	2.4	2.4	2.6	2.9	3.1	3.1	3.3	3.8	3.5	3.6	3.7	3.9	3.5	2.9	2.6	2.6	1.9
Netherlands	742	979	752	524	297	66	59	54	43	33	31	30	29	26	28	36	35
Norway	129	97	95	95	93	70	49	40	34	38	34	33	32	29	32	24	24
Portugal	18	18	18	18	18	18	19	21	18	17	15	11	11	11	11	9.2	10
Republic of Moldova	14	11	6.9	5.5	5.1	3.0	3.4	2.9	6.4	2.4	2.4	2.2	2.5	3.9	5.2	5.5	5.5
Romania	113	113	113	113	113	113	113	113	113	87	101	104	152	201	249	297	268
Serbia and Montenegro	172	172	172	172	172	172	172	172	172	172	172	170	169	167	166	164	162
Slovakia	136	132	128	124	120	116	106	96	109	98	90	87	91	70	65	86	67
Slovenia	16	17	15	14	13	12	12	12	11	11	11	10	10	10	9.1	8.6	8.4
Spain	181	187	195	192	186	161	160	133	134	140	147	141	142	147	150	150	155
Switzerland	175	159	149	137	122	105	96	88	81	63	54	42	29	17	16	16	16
The FYR of Macedonia	166	166	166	166	166	166	166	166	166	166	166	166	166	163	163	163	163
Turkey	1012	1012	1012	1012	1012	1012	1012	1012	1012	1012	1012	1018	1024	1029	1035	1041	1047
Ukraine	1022	1022	1022	1022	1022	1022	1022	1022	1022	1022	1022	1024	1026	1027	1029	1030	1032
United Kingdom	1146	1124	1097	889	692	739	476	379	284	258	229	218	201	199	227	199	197
<b>EMEP, kg TEQ/year</b>	<b>13</b>	<b>13</b>	<b>12</b>	<b>12</b>	<b>11</b>	<b>10</b>	<b>9.4</b>	<b>8.6</b>	<b>8.1</b>	<b>7.4</b>	<b>7.2</b>	<b>6.9</b>	<b>6.4</b>	<b>6.3</b>	<b>6.4</b>	<b>6.4</b>	<b>6.3</b>

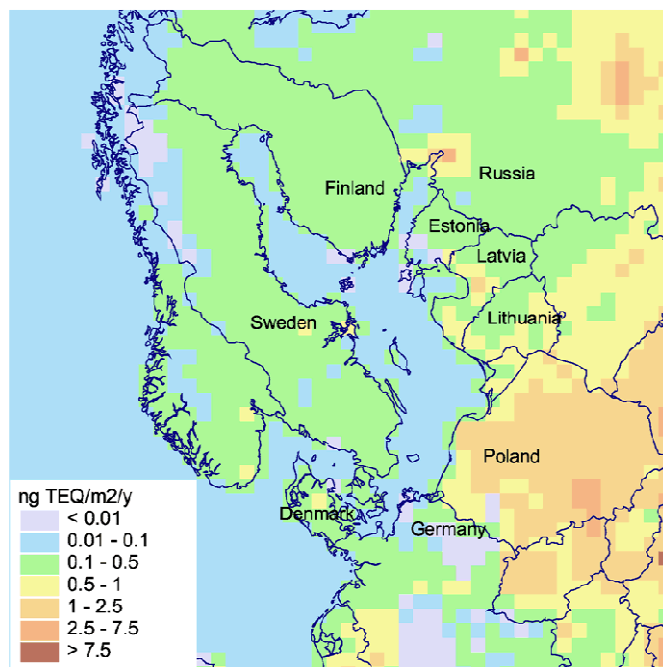
Expert estimates:

S Denier van der Gon, H.A.C., M. van het Bolscher A.J.H. Visschedijk P.Y.J. Zandveld [2006]



**Figure 7.19.** Time-series of total annual PCDD/F emissions of HELCOM countries in 1990-2006, g TEQ/year.

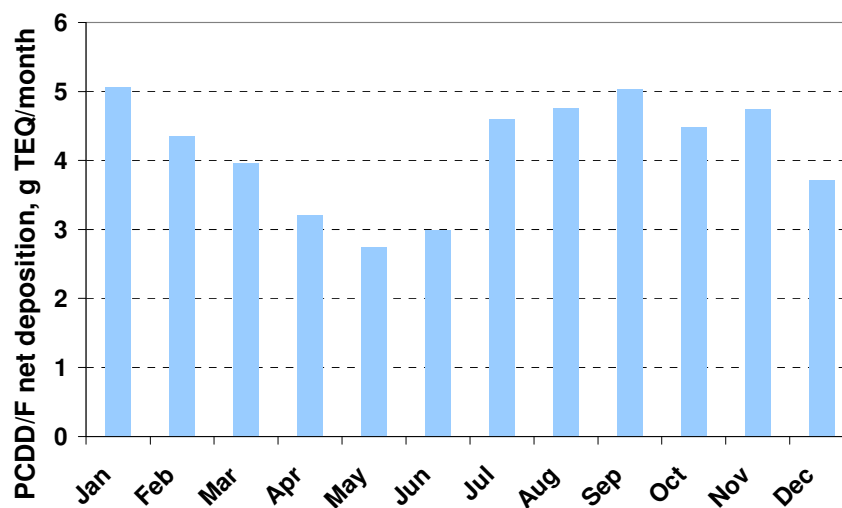
## 7.2 Annual net depositions of PCDD/F



**Figure 7.20.** Annual net deposition fluxes of PCDD/Fs over the Baltic Sea region for 2006, ng

TEQ/m<sup>2</sup>/year.

### 7.3 Monthly net depositions of PCDD/F

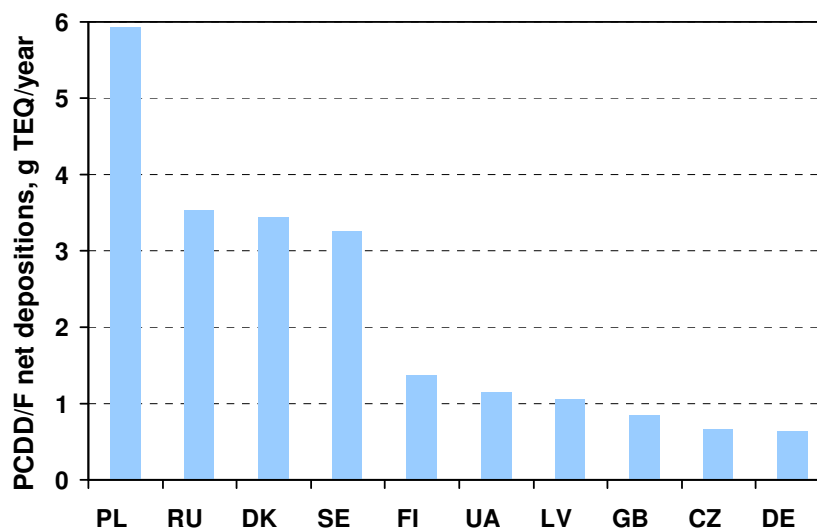


**Figure 7.21.** Monthly net depositions of PCDD/Fs over the Baltic Sea for 2006, g TEQ/month.

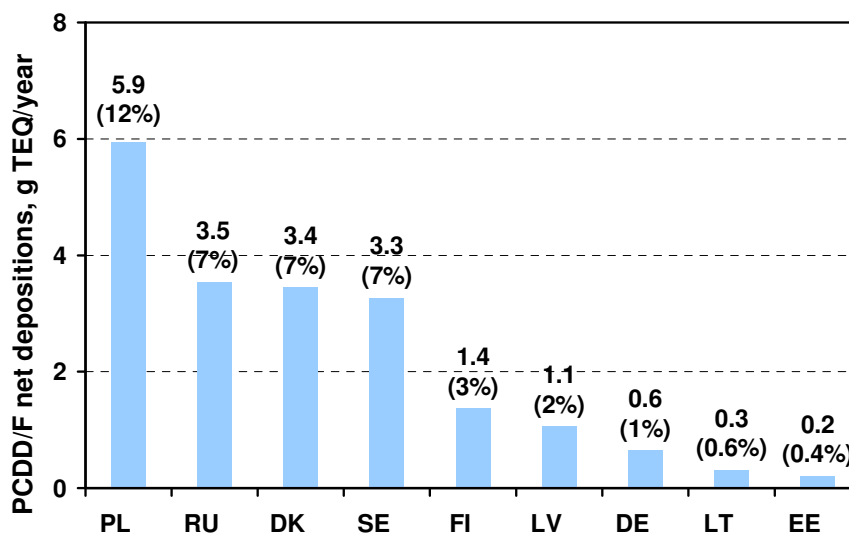
**Table 7.3.** Monthly net depositions of PCDD/Fs over the Baltic Sea for 2006, g TEQ/month.

Month	PCDD/Fs
<i>Jan</i>	5.1
<i>Feb</i>	4.4
<i>Mar</i>	4.0
<i>Apr</i>	3.2
<i>May</i>	2.7
<i>Jun</i>	3.0
<i>Jul</i>	4.6
<i>Aug</i>	4.8
<i>Sep</i>	5.0
<i>Oct</i>	4.5
<i>Nov</i>	4.7
<i>Dec</i>	3.7

## 7.4 Source allocation of PCDD/F deposition



**Figure 7.22.** Top ten countries with the highest contribution to annual deposition of PCDD/Fs over the Baltic Sea for 2006, g TEQ/y.



**Figure 7.23.** Contributions (in %) of HELCOM countries to the net PCDD/F depositions to the Baltic Sea for 2006. HELCOM countries emissions of PCDD/Fs contributed 40% to the net annual PCDD/F depositions over the Baltic Sea in 2006. Contribution of other EMEP countries accounted for 10%. Significant contribution was made by other emission sources, in particular, remote emissions sources and re-emission of PCDD/Fs (50%).

**Table 7.4.** Two most significant contributors to the annual net depositions of PCDD/Fs to the six Baltic Sea sub-basins for 2006.

<b>Sub-basin</b>	<b>Country (1)</b>	<b>%</b>	<b>Country (2)</b>	<b>%</b>	<b>*, %</b>
<b>GUB</b>	Sweden	16	Finland	12	51
<b>GUF</b>	Russia	46	Finland	4	35
<b>GUR</b>	Latvia	18	Poland	8	54
<b>BAP</b>	Poland	20	Sweden	6	51
<b>BES</b>	Denmark	29	Poland	4	52
<b>KAT</b>	Denmark	26	Sweden	5	51
<b>BAS</b>	Poland	12	Russia	7	50

\* - contribution of re-emission and remote sources.

## 7.5 Comparison of model results with measurements

PCDD/Fs are not currently included into the EMEP measurement programme. For this reason verification of the MSCE-POP model results for PCDD/Fs was based on the comparison with the data of various measurement campaigns. Due to the limited information on measured atmospheric levels of PCDD/Fs and their temporal variations the comparison with the model results for this contaminant is of a preliminary character.

The performance of MSCE-POP model for computation of PCDD/F pollution levels within the European region was evaluated during the model review carried out in the framework of EMEP Task Force on Monitoring and Measurements. In particular, MSCE-POP model results on long-range transport of one of the toxic PCDD/F congeners 2,3,4,7,8-PeCDF for the EMEP region and the period 1990-2003 were compared with measurements of EMEP monitoring network and observations of other studies within the European region (*Shatalov et al.*, 2005). One of the main conclusions of the TFMM Workshop on the Review of the EMEP Models on Heavy Metals and Persistent Organic Pollutants in Moscow in 2006 was that “the MSCE-POP model represents the state-of-the-science and fits to the purpose of evaluating the contributions of long-range transport to the environment impacts caused by POPs”. It was recognized that the MSCE-POP model results demonstrated its ability to provide spatially and temporally resolved air concentrations and depositions of POPs across Europe. The model provided reasonable agreement with long-term temporal trends of air pollution at most EMEP monitoring sites.

Additional comparison of PCDD/Fs modelling results obtained for 2004 was carried out with the

measurement data of monitoring campaign carried out in Denmark. The results of the comparison are presented in the Joint report of EMEP Centres for HELCOM (*Bartnicki et al.*, 2006).

In this report no results of comparison of modeling results with measurement is presented since there was no available measurements of dioxins and furans within the European region for 2006 were found.