

**Supporting Information for**

**Overview and perspectives on emissions of polybrominated diphenyl ethers on a global basis: Evaporative and fugitive releases from commercial PBDE mixtures and emissions from combustion sources**

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Table S1 Global bromine production derived from USGS National Minerals Information

Center using the data for 2003-2016.

Year	Bromine world production (U.S. production not included)	U.S.	Global Bromine Production
2016	391000	243000 <sup>a</sup>	634000
2015	342000	243000 <sup>a</sup>	585000
2014	409000	243000 <sup>a</sup>	652000
2013	389000	243000 <sup>a</sup>	632000
2012	357000	243000 <sup>a</sup>	600000
2011	380000	243000 <sup>a</sup>	623000
2010	371000	243000 <sup>a</sup>	614000
2009	301000	243000 <sup>a</sup>	544000
2008	415000	243000 <sup>a</sup>	658000
2007	415000	243000 <sup>a</sup>	658000
2006	671000	243000	914000
2005	654000	226000	880000
2004	577000	222000	799000
2003	494000	216000	710000

a: not disclosure since 2006, assuming U.S. production kept the same level in later years

Table S2 The cumulative PBDE production and use in polymers and textiles (tonnes) for 2007-2016

Homologue	Cumulative PBDE production			Cumulative PBDE use in polymers			Cumulative PBDE use in textiles		
	deca-BDE mixture	octa-BDE mixture	penta-BDE mixture	deca-BDE mixture	octa-BDE mixture	penta-BDE mixture	deca-BDE mixture	octa-BDE mixture	penta-BDE mixture
tri-BDE	0	0	0	0	0	0	0	0	0
tetra-BDE	0	0	0	0	0	0	0	0	0
penta-BDE	0	0	0	0	0	0	0	0	0
hexa-BDE	0	582	0	0	436	0	0	204	0
hepta-BDE	0	2327	0	0	1746	0	0	815	0
octa-BDE	0	1798	0	0	1349	0	0	629	0
nona-BDE	10820	529	0	8115	397	0	3787	185	0
deca-BDE	349838	52.9	0	262379	40	0	122443	19	0
Total	360658	5290	0	270494	3967	0	126230	1851	0

Table S3 The cumulative PBDEs in the landfills (tonnes) for 2007-2016

Homologue	deca-BDE mixture	octa-BDE mixture	penta-BDE mixture
tri-BDE	0	0	280
tetra-BDE	0	0	9532
penta-BDE	0	0	15981
hexa-BDE	0	2340	2243
hepta-BDE	0	9362	0
octa-BDE	0	7234	0
nona-BDE	6337	2128	0
deca-BDE	204907	213	0
Total	211244	21277	28036

Table S4 PBDE emission factors during production, use and waste management phases

	deca-BDE	nona-BDE	octa-BDE	hepta-BDE	hexa-BDE	penta-BDE	tetra-BDE	tri-BDE	reference
Production	2.40E-05	5.50E-05	5.50E-05	5.50E-05	5.50E-05	1.30E-04	1.30E-04	1.30E-04	
Use phase: polymer	3.90E-08	2.30E-07	1.40E-06	7.90E-06	4.60E-05	2.70E-04	1.60E-03	9.30E-03	(Alcock et al., 2003; Stevens et al., 2004; Sakai et al., 2006; Morf et al., 2007; Schenker et al., 2008)
Use phase: textile	9.50E-05	1.20E-04	1.60E-04	2.00E-04	2.60E-04	3.30E-04	4.20E-04	5.40E-04	
Landfill	6.10E-06	6.10E-06	6.10E-06	6.10E-06	6.10E-06	6.10E-06	6.10E-06	6.10E-06	
Use phases: textile	1.06E-08	5.88E-08	3.25E-07	1.63E-06	7.19E-06	3.02E-05	1.68E-04	9.61E-04	This study
Dismantling and crushing	3.0E-08	-	-	-	-	-	-	-	(Sakai et al., 2006)

Table S5 Percentage contributions of different sources to global PBDE evaporative and fugitive emissions

%	Emission factors of PBDE uses in textile materials obtained in this study					Emission factor of PBDE uses in textile materials obtained from literatures				
	production	Use: polymer	Use: textile	landfill	dismantlin g and crushing	production	Use: polymer	Use: textile	landfill	dismantlin g and crushing
tri-BDE	0	0	0	0.07	0	0	0	0	0.01	0
tetra-BDE	0	0	0	2.4	0	0	0	0	0.4	0
penta-BDE	0	0	0	4.0	0	0	0	0	0.7	0
hexa-BDE	0.1	0.1	0.06	1.1	0	0.02	0.1	0.4	0.2	0
hepta-BDE	0.4	0.1	0.05	2.3	0	0.07	0.09	1.1	0.4	0
octa-BDE	0.3	0.02	0.008	1.8	0	0.06	0.01	0.7	0.3	0
nona-BDE	2.2	0.02	0.01	2.1	0	0.4	0.01	3.2	0.3	0
deca-BDE	29.0	0.1	0.05	51.5	1.8	4.8	0.07	78.1	8.4	0.3
Total PBDEs	32.2	0.4	0.19	65.4	1.8	5.3	0.3	83.4	10.7	0.3

Table S6 Global PBDE emissions estimated from worldwide reported PCDD/F inventories using GM PBDE/PCDD/F ratios

Country or Region (Inventory year)	Important PCDD/F Emission Sources (g I-TEQ/year)	GM PBDE/PCDD/F I-TEQ Ratios from Wang et al. (2010)	Estimated PBDE Emission (kg/year)
USA (2000) (U.S. EPA, 2006)	Backyard barrel household refuse burning (472.6)	1980 <sup>d</sup>	936
	Medical waste/pathological incineration (357)	195	69.6
	Municipal waste combustion (76.3)	763	58.2
	Coal fire-utility boilers (70.4)	1420	100
	Vehicle fuel combustion - diesel on-road (Trucks) (61.7)	773	47.7
	Wood combustion – industrial (39.4)	116 <sup>i</sup>	4.57
	Vehicle fuel combustion - diesel off-road (31.4)	773	24.3
	Sintering plants (24.4)	82.1	2.00
	Cement kilns (hazardous waste burning) (16.6)	- <sup>b</sup>	-
	Wood combustion – residential (11.3)	116 <sup>i</sup>	1.31
The PCDD/F emissions inventory are based on U.S. specific data and internationally published PCDD/F emission factors.	Secondary ALSs (7.8)	1410	11.0
	Vehicle fuel combustion - unleaded gasoline on-road (6.7)	1140	7.64
	Subtotal of the above emission sources (1176)		1260
	Total emission of all PCDD/F emission sources, including unlisted sources (1244)		
	Percentage <sup>a</sup> (94.5 %)		

Country or Region (Inventory year)	Important PCDD/F Emission Sources (g I-TEQ/year)	GM PBDE/PCDD/F I-TEQ Ratios from Wang et al. (2010)	Estimated PBDE Emission (kg/year)
Canada (2001) (Canada, 2003)	Conical burners (44)	1980 <sup>d</sup>	87.1
	Medical waste incineration (25)	195	3.9
	Barrel burn (20)	1980 <sup>d</sup>	49.5
The PCDD/F emissions inventory are based on Canada specific data and internationally published PCDD/F emission factors.	Steel manufacturing: electric arc furnaces (11)	101	1.11
	Fuel combustion - diesel (traffic) (9)	773	6.96
	Municipal waste incineration (9)	763	6.87
	Hazardous waste incineration (7)	- <sup>b</sup>	-
	Iron manufacturing: sintering plants (6)	82.1	0.493
	Electric power generation (5)	1470	7.35
	Subtotal of the above emission sources (136)		163.3
	Total emission of all PCDD/F emission sources, including unlisted sources (164)		
	Percentage (82.9%)		



Country or Region (Inventory year)	Important PCDD/F Emission Sources (g I-TEQ/year)	GM PBDE/PCDD/F I-TEQ Ratios from Wang et al. (2010)	Estimated PBDE Emission (kg/year)
Chile (2002) (UNEP/GTZ/CONAMA, 2004)	Medical/hospital waste incineration (15.2)	195	2.96
	Fires/burning - biomass (15.0)	116 <sup>i</sup>	1.74
	Household heating and cooking – biomass (13.5)	116 <sup>i</sup>	1.56
PCDD/F emission estimates were made by using “Standardized Toolkit for the Identification of Quantification of Dioxin and Furan Releases” (The Toolkit for short, UNEP, 2005(UNEP, 2005))	Biomass power plants (4.45)	116 <sup>i</sup>	0.516
	Transportation (2.79)	957 <sup>g</sup>	2.67
	Iron ore sintering (1.32)	82.1	0.108
	Fossil fuel power boilers (1.16)	1470	1.71
	Aluminium production (0.72)	1410	1.02
	Iron and steel production plants and foundries (0.59)	101 <sup>f</sup>	0.0596
	Subtotal of the above emission sources (54.7)		12.3
	Total emission of all PCDD/F emission sources, including unlisted sources (51.7)		
	Percentage (105.9%)		

Country or Region (Inventory year)	Important PCDD/F Emission Sources (g I-TEQ/year)	GM PBDE/PCDD/F I-TEQ Ratios from Wang et al. (2010)	Estimated PBDE Emission (kg/year)
Argentina (2001) (Argentina, 2004)  PCDD/F emission estimates were made by using the Toolkit (UNEP, 2005)	Uncontrolled domestic waste burning (359)	1980 <sup>d</sup>	710.8
	Grassland and moor fires (118)	1000 <sup>j</sup>	118
	Forest fires (91.6)	116 <sup>i</sup>	10.6
	Medical/hospital waste incineration (79.53)	195	15.5
	Agricultural residue burning (in field) (31.04)	1000 <sup>j</sup>	31.04
	Biomass power plants (22.9)	116 <sup>i</sup>	2.66
	Iron ore sintering (9.5)	82.1	0.780
	Iron and steel plants (8.94)	101	0.903
	Copper production (5.85)	756 <sup>e</sup>	4.42
	Transportation (3.08)	957 <sup>g</sup>	2.95
	Fossil fuel/waste co-fired power boilers (2.61)	1470	3.84
	Aluminium production (1.57)	1410	2.21
	Subtotal of the above emission sources (733.62)		904
	Total emission of all PCDD/F emission sources, including unlisted sources (874)		
Percentage (83.9%)			

Country or Region (Inventory year)	Important PCDD/F Emission Sources (g I-TEQ/year)	GM PBDE/PCDD/F I-TEQ Ratios from Wang et al. (2010)	Estimated PBDE Emission (kg/year)
Cuba (2000) (Cuba, 2003)  PCDD/F emission estimates were made by using the Toolkit (UNEP, 2005)	Biomass power plants (55.2)	116 <sup>i</sup>	6.40
	Uncontrolled domestic waste burning (48.2)	1980 <sup>d</sup>	95.4
	Medical/hospital waste incineration (31.5)	195	6.14
	Animal carcasses burning (23.5)	- <sup>b</sup>	-
	Agricultural residue burning (in field) (16.8)	1000 <sup>j</sup>	16.8
	Iron and steel production plants and foundries (3.45)	101	0.348
	Copper production (2.38)	756 <sup>e</sup>	1.80
	Aluminium production (0.50)	1410	0.705
	Transportation (0.42)	957 <sup>g</sup>	0.402
	Subtotal of the above emission sources (181.95)		128
Total emission of all PCDD/F emission sources, including unlisted sources (195)			
Percentage (93.3%)			

Country or Region (Inventory year)	Important PCDD/F Emission Sources (g I-TEQ/year)	GM PBDE/PCDD/F I-TEQ Ratios from Wang et al. (2010)	Estimated PBDE Emission (kg/year)
Uruguay (2003) (Uruguay, 2005)	Uncontrolled domestic waste burning (8.56)	1980 <sup>d</sup>	16.9
	Agricultural residue burning (in field) (2.94)	1000 <sup>j</sup>	2.94
	Transportation (1.3)	957 <sup>g</sup>	1.24
	Household heating and cooking – biomass (1.28)	116 <sup>i</sup>	0.148
	Medical/hospital waste incineration (0.954)	195	0.186
	Biomass power plants (0.589)	116 <sup>i</sup>	0.0683
	Aluminium production (0.572)	1410	0.807
PCDD/F emission estimates were made by using the Toolkit (UNEP, 2005)	Fossil fuel/waste co-fired power boilers (0.035)	1470	0.0515
	Subtotal of the above emission sources (16.2)		22.4
	Total emission of all PCDD/F emission sources, including unlisted sources (18.7)		
	Percentage (86.8%)		

Country or Region (Inventory year)	Important PCDD/F Emission Sources (g I-TEQ/year)	GM PBDE/PCDD/F I-TEQ Ratios from Wang et al. (2010)	Estimated PBDE Emission (kg/year)
Colombia (2002) (Colombia, 2007)  PCDD/F emission estimates were made by using the Toolkit (UNEP, 2005)	Landfill fires (142)	1980 <sup>d</sup>	281
	Medical/hospital waste incineration (88.4)	195	17.2
	Accidental fires in houses, factories (73.6)	- <sup>b</sup>	-
	Bush fires (52.2)	1000 <sup>j</sup>	52.2
	Uncontrolled domestic waste burning (24.9)	1980 <sup>d</sup>	49.3
	Virgin wood/biomass fired stoves (7.16)	116 <sup>i</sup>	0.831
	Coal fired stoves (6.72)	1420	9.54
	Foundries (6.37)	101 <sup>f</sup>	0.643
	Municipal solid waste incineration (6.31)	763	4.81
	Iron and steel plants (4.95)	101	0.50
	Wood fired power boilers (3.95)	116 <sup>i</sup>	0.458
	Copper production (2.47)	756 <sup>e</sup>	1.87
	Transportation (1.99)	957 <sup>g</sup>	1.904
	Aluminium production (0.58)	1410	0.818
	Subtotal of the above emission sources (421.6)		421
Total emission of all PCDD/F emission sources, including unlisted sources (479)			
Percentage (88%)			

Country or Region (Inventory year)	Important PCDD/F Emission Sources (g I-TEQ/year)	GM PBDE/PCDD/F I-TEQ Ratios from Wang et al. (2010)	Estimated PBDE Emission (kg/year)
Paraguay (2002) (Paraguay, 2003)	Uncontrolled domestic waste burning (37.6)	1980 <sup>d</sup>	74.4
	Agricultural residue burning (in field) (20.2)	1000 <sup>j</sup>	20.2
	Medical/hospital waste incineration (3.50)	195	0.683
	Household heating and cooking - biomass (3.06)	116 <sup>i</sup>	0.355
PCDD/F emission estimates were made by using the Toolkit (UNEP, 2005)	Coke production (1.52)	- <sup>b</sup>	-
	Transportation (0.37)	957 <sup>g</sup>	0.354
	Subtotal of the above emission sources (66.3)		96.0
	Total emission of all PCDD/F emission sources, including unlisted sources (70.66)		
	Percentage (93.8%)		
Ecuador (2002) (UNEP/GTZ/CONA MA, 2004)	Agricultural residue burning (in field) (23.9)	1000 <sup>j</sup>	23.9
	Medical/hospital waste incineration (10.1)	195	1.97
	Ferrous and non-ferrous metal production (6.91)	756 <sup>e</sup>	5.22
	Household heating and cooking – biomass (5.4)	116 <sup>i</sup>	0.626
	Transportation (0.48)	957 <sup>g</sup>	0.459
PCDD/F emission estimates were made by using the Toolkit (UNEP, 2005)	Subtotal of the above emission sources (46.8)		32.2
	Total emission of all PCDD/F emission sources, including unlisted sources (65.5)		
	Percentage (71.4%)		

Country or Region (Inventory year)	Important PCDD/F Emission Sources (g I-TEQ/year)	GM PBDE/PCDD/F I-TEQ Ratios from Wang et al. (2010)	Estimated PBDE Emission (kg/year)
European Union countries <sup>c</sup> (2000) (European Commission, 2000)	Residential combustion: Boilers, stoves, fireplaces: wood (532-971, mean: 747)	116 <sup>i</sup>	86.7
	Sinter plants (447-554, mean: 500.5)	82.1	41.1
	Incineration of municipal wastes (412-506, mean: 459)	763	350
	Incineration of hospital wastes (96-392, mean: 244)	195	47.6
The PCDD/F inventory has been based on actual measurements of PCDD/F releases from sources in various countries of the European Union.	Residential combustion: boilers, stoves, fireplaces: coal/lignite (86-370, mean: 228)	- <sup>b</sup>	-
	Incineration of municipal wastes: illegal (domestic) combustion (126-200, mean: 163)	1980 <sup>d</sup>	323
	Incineration of industrial wastes (131-166, mean: 148.5)	96.6	14.3
	Electric furnace steel plants (120-153, mean: 136.5)	101	13.8
	Power plants (55-72, mean: 63.5)	1470	93.3
	Road transport (37-82, mean: 59.5)	957 <sup>g</sup>	56.9
	Combustion in industry/boilers, gas turbines, stationary engines (34-81, mean: 57.5)	1470	84.5
	Secondary aluminium production (27-72, mean 49.5)	1410	69.8
	Subtotal of the above emission sources (2857)		1180
	Total emission of all PCDD/F emission sources, including unlisted sources (2465-4605, mean: 3535)		
Percentage (80.8%)			

Country or Region (Inventory year)	Important PCDD/F Emission Sources (g I-TEQ/year)	GM PBDE/PCDD/F I-TEQ Ratios from Wang et al. (2010)	Estimated PBDE Emission (kg/year)
Poland (2000) (Poland, 2002)  The PCDD/F inventory has been based partly on actual measurements of PCDD/F releases from sources in Poland, and partly on emission factors derived from experience in other countries.	Uncontrolled waste burning (100)	1980 <sup>d</sup>	198
	Hazardous waste incineration (77)	- <sup>b</sup>	-
	Industrial waste incineration (53)	96.6	5.12
	Landfill fires (49)	1980 <sup>d</sup>	97.0
	Iron ore sintering (40)	82.1	3.28
	Household heating and cooking – biomass (29)	116 <sup>i</sup>	3.36
	Aluminium production (19)	1410	26.8
	Accidental fires in vehicles and houses (17)	- <sup>b</sup>	-
	Fossil fuel power plants (16)	1470	23.5
	Domestic heating - fossil fuels (16)	1470 <sup>h</sup>	23.5
	Fires/burnings – biomass (14)	116 <sup>i</sup>	1.62
	Medical/hospital waste incineration (12)	195	2.34
	Iron and steel plants (11)	101	1.11
	Foundries (3.9)	101 <sup>f</sup>	0.394
Transportation (3.6)	957 <sup>g</sup>	3.45	
Copper production (2.3)	756 <sup>e</sup>	1.74	
Subtotal of the above emission sources (462.8)		386.4	
Total emission of all PCDD/F emission sources, including unlisted sources (490)			
Percentage (94.4%)			



Country or Region (Inventory year)	Important PCDD/F Emission Sources (g I-TEQ/year)	GM PBDE/PCDD/F I-TEQ Ratios from Wang et al. (2010)	Estimated PBDE Emission (kg/year)
Croatia (2001) (Croatia, 2003)	Non-industrial combustion plants – wood (90.7)	116 <sup>i</sup>	10.5
	Combustion in manufacturing industry – wood (10.4)	116 <sup>i</sup>	1.21
	Steel production (4.97)	101	0.502
	Waste treatment - incinerator (0.28)	763	0.214
	Road transportation (0.13)	957 <sup>g</sup>	0.124
PCDD/F emission estimates were made by using the Toolkit (UNEP, 2005)	Subtotal of the above emission sources (106.5)		12.6
	Total emission of all PCDD/F emission sources, including unlisted sources (109)		
	Percentage (97.7%)		
	<hr/>		
Australia (2002) (Australian, 2004)	Biomass burning (240)	116 <sup>i</sup>	27.84
	Landfill fires (79)	1980 <sup>d</sup>	156.4
The PCDD/F emissions inventory are based on Australian specific data and internationally published PCDD/F emission factors.	Zinc production (50)	756 <sup>e</sup>	37.8
	Metal ore sintering (32)	82.1	2.63
	Iron and steel production plants (20.3)	101	2.05
	Household heating and cooking with biomass (20.2)	116 <sup>i</sup>	2.34
	Fossil fuel power plants (14.3)	1470	21.02
	Accidental building fires (8)	- <sup>b</sup>	-
	Medical waste incineration (6.39)	195	1.25
	Diesel engines (5.4)	773	4.17
	Aluminium production (4.45)	1410	6.27
	Subtotal of the above emission sources (480)		262
	Total emission of all PCDD/F emission sources, including unlisted sources (500)		
	Percentage (96%)		

Country or Region (Inventory year)	Important PCDD/F Emission Sources (g I-TEQ/year)	GM PBDE/PCDD/F I-TEQ Ratios from Wang et al. (2010)	Estimated PBDE Emission (kg/year)
Taiwan (2005) (Taiwan EPA, 2006)	EAF fly ash treatment plant (39.392)	101	3.98
	EAFs (35.310)	101	3.57
	Sinter plants (5.765)	82.1	0.473
	Power plants (fuel) (4.307)	1510	6.50
	Secondary ALSs (2.413)	1410	3.40
The PCDD/F emissions inventory are based on Taiwan specific data and internationally published PCDD/F emission factors.	Road transport (2.296)	957 <sup>b</sup>	2.20
	MSWIs (2.049)	763	1.56
	IWIs (1.134)	96.6	0.110
	Power plants (coal) (0.700)	1420	0.994
	MWIs (0.175)	195	0.0341
	Batch MSWIs (0.046)	1980	0.0911
	Subtotal of the above emission sources (93.587)		22.9
	Total emission of all PCDD/F emission sources, including unlisted sources (100.421)		
	Percentage (93.2%)		

Country or Region (Inventory year)	Important PCDD/F Emission Sources (g I-TEQ/year)	GM PBDE/PCDD/F I-TEQ Ratios from Wang et al. (2010)	Estimated PBDE Emission (kg/year)
Japan (2005) (Japan, 2006)	Batch MSWIs (74-96, mean: 85)	1980	168
	IWIs (73)	96.6	7.05
	MSWIs (62)	763	47.3
	EAFs (49.6)	101	5.01
	Sinter plants (29.3)	82.1	2.41
The PCDD/F emissions inventory are most based on Japan specific data.	Secondary ALSs (13.1)	1410	18.5
	Crematories (2.4-5.3, mean: 3.85)	- <sup>b</sup>	-
	Power plants (2.15)	1470	3.16
	Road transport (1.2)	957 <sup>g</sup>	1.15
	Subtotal of the above emission sources (319.2)		253
	Total emission of all PCDD/F emission sources, including unlisted sources (323-348, mean: 335.5)		
	Percentage (95.1%)		

Country or Region (Inventory year)	Important PCDD/F Emission Sources (g I-TEQ/year)	GM PBDE/PCDD/F I-TEQ Ratios from Wang et al. (2010)	Estimated PBDE Emission (kg/year)
China (2002) (Jin et al., 2004)	Iron and steel (127.4-1820, mean: 973.7)	101	98.3
	Sinter plant (144-1080, mean: 612)	82.1	50.2
	Municipal solid waste incinerators (3.20-924, mean: 463.6)	763	354
	Cement kilns (210.25)	- <sup>b</sup>	-
	Non-ferrous metal (50.6-354.2, mean: 202.4)	756 <sup>e</sup>	153
	Crematoria (9.96-332, mean: 171)	- <sup>b</sup>	-
	Coal power plants (50.19)	1420	71.3
The PCDD/F emissions inventory are based on internationally published PCDD/F emission factors.	Residential coal combustion (16.38-72.52, mean: 44.45)	- <sup>b</sup>	-
	Coke production (42.84)	- <sup>b</sup>	-
	Subtotal of the above emission sources (2770)		727
	Total emission of all PCDD/F emission sources, including unlisted sources (2773)		
	Percentage (99.9%)		
Brunei Darussalam (2001) (Brunei Darussalam, 2003)	Medical/hospital waste incineration (585)	195	114
	Diesel engines (58.6)	773	45.3
	Forest fires (27.5)	116 <sup>i</sup>	3.19
	Fossil fuel power plants (19.8)	1470	29.1
	Agricultural residue burning (in field) (9.75)	1000 <sup>j</sup>	9.75
	Two-stroke engines (8.32)	1140	9.48
	Grassland and moor fires (5.14)	1000 <sup>j</sup>	5.14
PCDD/F emission estimates were made by using the Toolkit (UNEP, 2005)	Subtotal of the above emission sources (714.1)		216
	Total emission of all PCDD/F emission sources, including unlisted sources (749)		
	Percentage (95.3%)		

Country or Region (Inventory year)	Important PCDD/F Emission Sources (g I-TEQ/year)	GM PBDE/PCDD/F I-TEQ Ratios from Wang et al. (2010)	Estimated PBDE Emission (kg/year)
	Household heating and cooking – biomass (3.55)	116 <sup>i</sup>	0.412
	Fires/burnings – biomass (2.69)	116 <sup>i</sup>	0.312
	Medical/hospital waste incineration (2.60)	195	0.507
	Transportation (0.979)	957 <sup>g</sup>	0.937
Vietnam (2002)	Fossil fuel power plants (0.812)	1470	1.194
(Vietnam, 2003)	Hazardous waste incineration (0.272)	- <sup>b</sup>	-
	Iron and steel production plants and foundries (0.247)	101 <sup>f</sup>	0.0230
PCDD/F emission	Aluminium production (0.189)	1410	0.266
estimates were made	Municipal solid waste incineration (0.17)	763	0.130
by using the Toolkit	Biomass power plants (0.121)	116 <sup>i</sup>	0.0140
(UNEP, 2005)	Iron ore sintering (0.05)	82.1	0.00411
	Subtotal of the above emission sources (11.7)		3.80
	Total emission of all PCDD/F emission sources, including unlisted sources (15.97)		
	Percentage (73.1%)		

Country or Region (Inventory year)	Important PCDD/F Emission Sources (g I-TEQ/year)	GM PBDE/PCDD/F I-TEQ Ratios from Wang et al. (2010)	Estimated PBDE Emission (kg/year)	
Jordan (2000) (Jordan, 2003)	Landfill fires (44.4)	1980 <sup>d</sup>	87.9	
	Medical waste incineration (3.82)	195	0.745	
	Iron and steel production (1.38)	101	0.139	
	Uncontrolled domestic waste burning (2.7)	1980 <sup>d</sup>	5.35	
	Aluminum production (1.13)	1410	1.59	
	Transportation (0.768)	957 <sup>g</sup>	0.735	
	Subtotal of the above emission sources (54.2 )		96.5	
PCDD/F emission estimates were made by using the Toolkit (UNEP, 2005)	Total emission of all PCDD/F emission sources, including unlisted sources (53.6)			
	Percentage (101.1%)			
	Thailand (2005) (Tangbanluekal, 2007)	Uncontrolled domestic waste burning (118)	1980 <sup>d</sup>	234
		Medical/hospital waste incineration (38.3)	195	7.47
		Biomass power plants (27.9)	116 <sup>i</sup>	3.24
		Crematories (21.6)	- <sup>b</sup>	-
		Iron and steel production & foundries (19.9)	101 <sup>f</sup>	2.01
		Agricultural residue burning (in field) (19.9)	1000 <sup>j</sup>	19.9
		Diesel engines (8.28)	773	6.40
	PCDD/F emission estimates were made by using the Toolkit (UNEP, 2005)	Fossil fuel power plants (4.54)	1470	6.67
Municipal solid waste incineration (4.07)		763	3.11	
Two-Stroke engines (2.64)		1140	3.01	
Subtotal of the above emission sources (265.13 )			285	
Total emission of all PCDD/F emission sources, including unlisted sources (286)				
Percentage (92.7%)				

Country or Region (Inventory year)	Important PCDD/F Emission Sources (g I-TEQ/year)	GM PBDE/PCDD/F I-TEQ Ratios from Wang et al. (2010)	Estimated PBDE Emission (kg/year)
Philippines (1999) (Philippines, 2003)  PCDD/F emission estimates were made by using the Toolkit (UNEP, 2005)	Agricultural residue burning (in field) (124)	1000 <sup>j</sup>	124
	Biomass power plants (107)	116 <sup>i</sup>	12.4
	Medical/hospital waste incineration (37.7)	195	7.35
	Virgin wood/biomass fired stoves (34.3)	116 <sup>i</sup>	3.98
	Foundries (5.4)	101 <sup>f</sup>	0.545
	Fossil fuel power plants (1.29)	1470	1.90
	Iron ore sintering (1.26)	82.1	0.103
	Aluminum production (0.703)	1410	0.991
	Transportation (0.12)	957 <sup>g</sup>	0.115
	Subtotal of the above emission sources (311.773)		151
	Total emission of all PCDD/F emission sources, including unlisted sources (328)		
	Percentage (95.1%)		
Lebanon (2004) (Lebanon, 2005)  PCDD/F emission estimates were made by using the Toolkit (UNEP, 2005)	Uncontrolled domestic waste burning (39.2)	1980 <sup>d</sup>	101
	Medical waste incineration (13.2)	195	1.83
	Transportation (0.149)	957 <sup>g</sup>	2.25
	Aluminum production (0.138)	1410	1.00
	Subtotal of the above emission sources (63.63 )		106.5
	Total emission of all PCDD/F emission sources, including unlisted sources (79)		
	Percentage (80.5%)		

<sup>a</sup> Contribution (%) of the listed emission sources (subtotal) to the total PCDD/F emissions

<sup>b</sup> Possible sources of PBDE emissions; data unavailable

<sup>c</sup> Including Austria, Belgium, Switzerland, Germany, Denmark, Spain, France, Greece, Italy, Ireland, Luxembourg, Norway, The Netherlands,

Portugal, Sweden, Finland, and United Kingdom

<sup>d</sup> Ratio from batch MSWI emissions

<sup>e</sup> Average ratio from EAF and secondary ALS emissions

<sup>f</sup> Ratio from EAF emissions

<sup>g</sup> Average ratio from UGFV and DFV emissions

<sup>h</sup> Ratio from power plant emissions

<sup>i</sup> Ratio from wood chip boiler emission

<sup>i</sup> Ratio from rice straw open burning in the study of Chang et al. (2014)



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