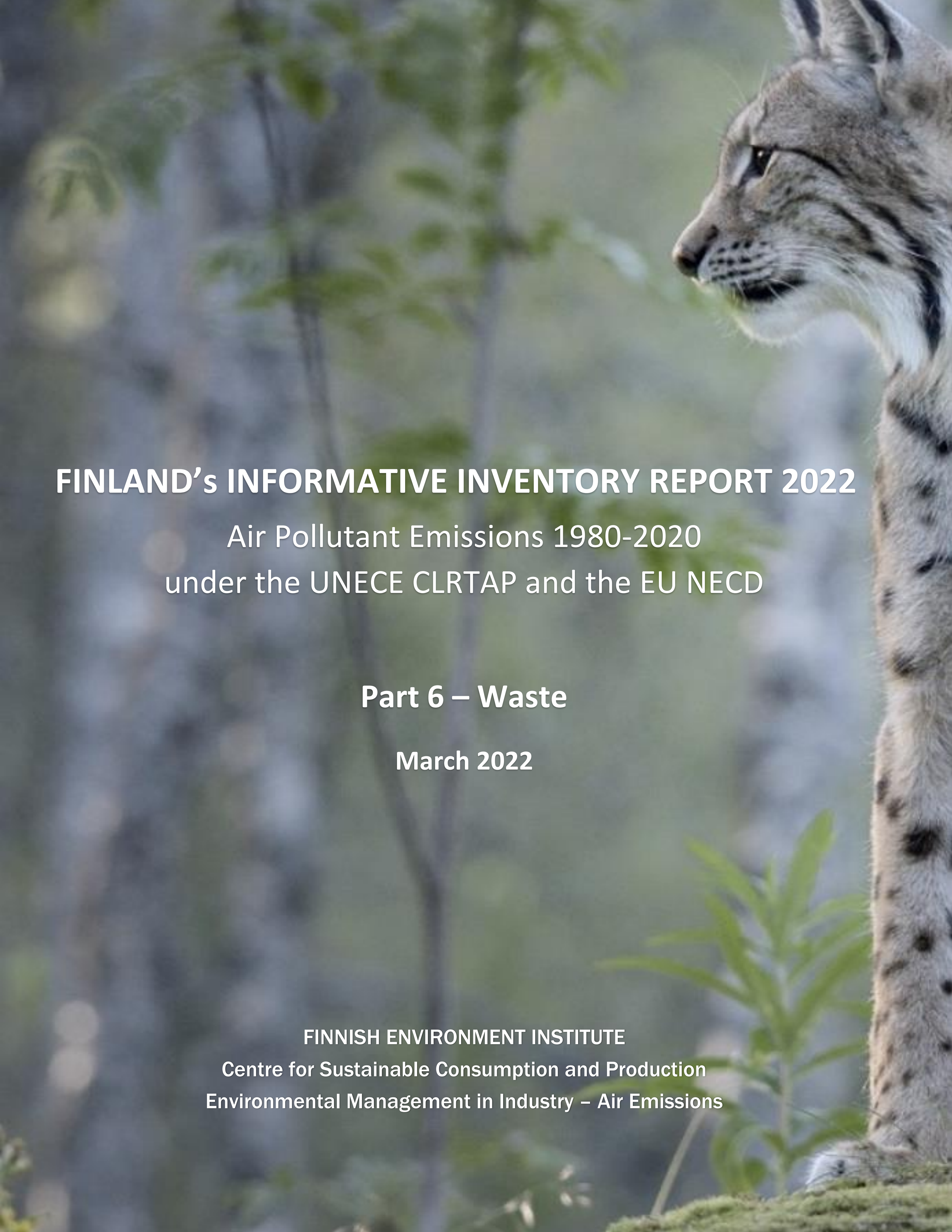

FINLAND's INFORMATIVE INVENTORY REPORT 2022

Air Pollutant Emissions 1980-2020
under the UNECE CLRTAP and the EU NECD

Part 6 – Waste

March 2022

FINNISH ENVIRONMENT INSTITUTE
Centre for Sustainable Consumption and Production
Environmental Management in Industry – Air Emissions

Finland's IIR
Part 6
Waste Sector

Cover page picture: Lynx (MEK 2019)

IIR - PART 6 - WASTE

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6 WASTE (NFR 5)

Changes in chapter	
February 2022	KS, JMP

6.1 Source category description

Emissions from solid waste disposal on land (landfills), waste incineration, wastewater treatment, latrines, composting, cremation and other waste (house and car fires) are included in under the Waste sector inventory as presented in Table 6.1.

Emissions from waste incineration are reported under NFR 1A1a or NFR 1A2gviii because all waste incineration occurring in Finland is with energy recovery. However, documentation on the methods used is presented under Waste Incineration 5C.

Air pollutant emission levels from the waste sector are minor compared to the levels of greenhouse gases.

Table 6.1 Emission categories and reported emissions under NFR 5 in 2020.

NFR	Processes	Description	Emissions reported
5 A	Biological treatment of waste – Solid waste disposal on land	solid municipal, industrial, construction and demolition wastes	NMVOC, TSP, PM_{10}, $PM_{2.5}$
5 B 1	Biological treatment of waste - Composting	biowaste, municipal solid waste, municpal and industrial sludges and industrial solid waste	NH_3
5 B 2	Biological treatment of waste – Anaerobic digestion at biogas facilities	covers biogas reactor plants at municipal and industrial wastewater treatment plants	NH_3
5 C 1 a	Municipal waste incineration	No waste incineration occurs, all waste is combusted with energy recovery	-
5 C 1 bi	Industrial waste incineration		-
5 C 1 bii	Hazardous waste incineration	IE, emissions are allocated under energy sector, all waste incineration includes energy recovery	-
5 C 1 biii	Clinical waste incineration	Waste incineration occurred only in 1990-1993, all waste is combusted with energy recovery thereafter	-
5 C 1 biv	Sewage sludge incineration	No waste incineration occurs, all waste is combusted with energy recovery	-
5 C 1 bv	Cremation	part of emissions IE (under 1A1)	$PM_{2.5}$, PM_{10}, TSP, BC, Pb, Cd, Hg, As, Cr, Cu, Ni, Zn, PCDD/F, PAH-4, PCB, HCB
5 C 1 bvi	Other waste incineration	No waste incineration occurs, all waste is combusted with energy recovery	-
5 C 2	Open burning of waste	Not Occuring	-
5 D 1	Domestic wastewater handling	wastewater handling, domestic, latrines	NMVOC, NH_3
5 D 2	Industrial wastewater handling	wastewater hanglind, industrial	NMVOC
5 D 3	Other wastewater handling	Not Occuring	-
5 E	Other waste	car and house fires	$PM_{2.5}$, PM_{10}, TSP, BC, Pb, Cd, Hg, As,Cr, Cu, PCDD/F

Information on population as background data is presented in Table 6.2 for both urban and total population.

Table 6.2 Background data (total population and population in urban areas) related to the waste sectors in 1990-2020 (Statistic Finland, 2022).

Year	Total population	Urban population	Year	Total population	Urban population
1990	4998478	3095607	2006	5276955	3519288
1991	5029002	3127655	2007	5300484	3547955
1992	5054982	3153984	2008	5326314	3583254
1993	5077912	3182285	2009	5351427	3613215
1994	5098754	3211868	2010	5375276	3641874
1995	5116826	3242380	2011	5401267	3674047
1996	5132320	3267456	2012	5426674	3708852
1997	5147349	3294625	2013	5451270	3741991
1998	5159646	3320011	2014	5471753	3772872
1999	5171302	3347508	2015	5487308	3797978
2000	5181115	3372096	2016	5503297	3829719
2001	5194901	3401057	2017	5513130	3856747
2002	5206295	3423255	2018	5517919	3881481
2003	5219732	3444416	2019	5525292	3964111
2004	5236611	3467411	2020	5533793	3992546
2005	5255580	3491993			

6.2 Solid waste disposal on land (NFR 5A)

Changes in chapter	
February 2022	KS, JMP

Source category description

Under NFR 5A Finland reports NMVOC emissions from disposal of solid municipal, industrial, construction and demolition wastes, as well as municipal (domestic) and industrial sludges. The emission reporting under the UNECE CLRTAP, the EU NECD and the UNFCCC are consistent.

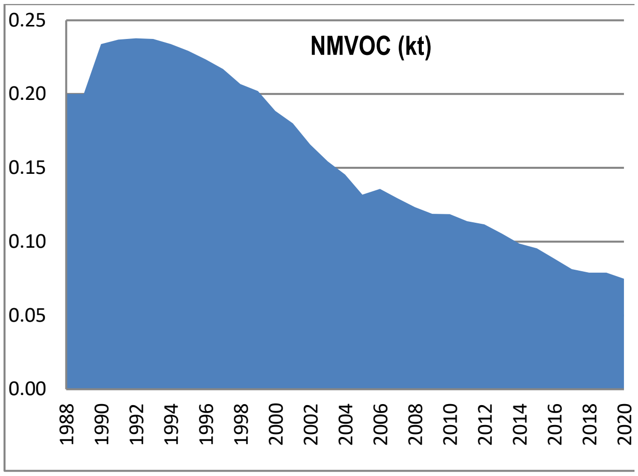
The energy produced in waste incineration is utilised and the emissions are therefore reported in the Energy sector. Implementation of landfill gas recovery has also had a significant decreasing impact on the emissions.

The category is not a key category for any pollutants.

Emission trend

After the implementation of the revised Waste Act (1994), the Landfill Directive (1999/31/EC) and the ban of organic waste to landfills since 2016 (Government Decree 2013) minimisation of waste generation, recycling and reuse of waste material, landfill gas recovery and alternative treatment methods to landfills have been endorsed. Similar developments have occurred in the treatment of industrial waste, and municipal and industrial sludges. While the emissions from solid waste disposal on lands have decreased, the emissions from composting have increased until 2007 where after the changes in the emissions have been small. In addition, the increase of waste incineration has decreased the emissions from landfills from 2008 onwards.

NMVOC and particle emissions from NFR 5A are presented in Figure 6.1.



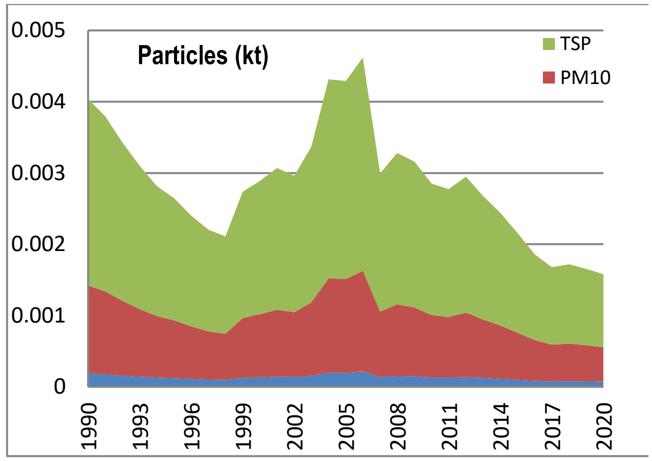


Figure 6.1 NMVOC and particle emissions reported under NFR 5A

Contribution of NFR 5A to total emissions and the shares of emissions reported by the plants are presented in Table 6.3.

Table 6.3 Contribution of Biological treatment of waste – solid waste disposal on land (NFR 5A) to total emissions in 2020.

Pollutant	Emissions from solid waste disposal on land	Total emissions	Unit	Share of total emissions %	% reported by the plants
NMVOC	0.075	84.587	Gg	<0.1	0
PM2.5	<0.001	14.062	Gg	<0.1	0
PM10	<0.001	26.564	Gg	<0.1	0
TSP	0.001	39.486	Gg	<0.1	0

Methodological issues

NMVOC emissions

NMVOC emissions from solid waste disposal on land are calculated using the same method as in calculation of greenhouse gases described in the Finnish NIR (http://www.stat.fi/tup/khkinv/khkaasut_raportointi_en.html), where methane emissions and the volume of landfill gas have been calculated using the First Order Decay (FOD) method.

The calculation of NMVOC emissions is based on the NMVOC concentration in landfill gas taking into account the recovery rate and other reductions. NMVOC concentration in the landfill gas is assumed to be 485 mg/m^3 (Myllyperkiö, 2005) based on the average of studies carried out in the US in 1998, in Germany in 1999 and in Finland in 1990, and has been estimated to correspond sufficiently to the Finnish conditions. The volume of landfill gas is derived from the density of methane (0.718 kg/m^3) and from the fraction of CH_4 in landfill gas (0.5).

Activity data

The total amount of waste taken to landfills from 1997 onwards is used as activity data in the calculation of methane emissions. This activity data is available in YLVA system and includes information on all landfills in Finland excluding the Åland territory, for which an estimate according to the population is used. The waste amount data are registered according to the EWC (European Waste Catalogue) classification (both EWC 1997 and EWC 2002). Sampling routines have been developed to convert the classification used in VAHTI to the classification used in the emission estimations. Corresponding data (but with volume units and the waste classification is less detailed) for the years 1992-1996 were collected to the Landfill Registry of the Finnish Environment Institute. The activity data for municipal waste for the year 1990 are based on the estimates of the Advisory Board for Waste Management (1992) for municipal solid waste generation and treatment in Finland in 1989 with the correction of double counting in paper waste. The disposal data (amount and composition) at the beginning of the 1990's for industrial, construction and demolition waste are based on surveys and research by Statistics Finland (Isaksson 1993; Puolamaa et al., 1995), VTT Technical Research Centre of Finland (Perälä & Nippala 1998; Pipatti et al. 1996) and the National Board of Waters and the Environment (Karhu 1993). For base year activity data Isaksson (1993) and Pipatti et al. (1996) are used for construction and demolition waste. Karhu (1993) is used for industrial sludges and Puolamaa et al. (1995) is used for solid industrial waste. (Finland's GHG NIR, 2017)

The amount of landfilled waste in is presented in Table 6.4 and additional background data in Table 6.5. As it can be seen in Table 6.4 the amount of municipal solid waste has decreased significantly since 1990. This is due the increased energy use of wastes and this trend will continue in the future, also.

Table 6.4 Landfilled waste (1 000 t). Sources: YLVA database, Landfill Registry of the Finnish Environment Institute. Advisory Board for Waste Management 1992, Vahvelainen & Isaksson 1992, Isaksson 1993, Pipatti et al. 1996, Puolamaa et al. 1995, Perälä & Nippala 1998, Karhu 1993. Directly or indirectly interpolated values are presented in italics. (Finland's NIR, 2022)

Waste group	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**19966**	**1997**	**1998**	**1999**
Municipal solid waste	2 400	*2 230*	2 070	1 909	1 725	1 682	*1 599*	1 535	1 528	1 586
Municipal sludge (d.m.)	47	*48*	48	*47*	46	25	21	7	6	5
Municipal sludge (wet m.)	498	*504*	510	*505*	501	298	212	84	71	67
Industrial sludge (d.m.)	337	*318*	299	*285*	*268*	*260*	*248*	229	182	140
Industrial sludge (wet m.)	1 193	*1 129*	1 065	*999*	*935*	*881*	*790*	695	606	559
Industrial solid waste	2 135	2 107	2 079	1 892	1 706	1 519	1 332	1 146	1 345	2 316
Constr. and demol. waste	1 262	*1 110*	*781*	*667*	*639*	*637*	*567*	540	438	415

Waste group	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Municipal solid waste	1 602	1 542	1 507	1 488	1 423	1 462	1 485	1 411	1 358	1 128
Municipal sludge (d.m.)	6	8	6	6	6	6	5	4	4	3
Municipal sludge (wet m.)	70	79	66	63	58	53	51	39	27	26
Industrial sludge (d.m.)	118	97	65	42	29	48	44	32	15	18
Industrial sludge (wet m.)	550	329	209	198	127	161	144	119	49	55
Industrial solid waste	2 390	2 659	2 562	3 041	4 781	4 682	5 142	2 996	3 435	3 570
Constr. and demol. waste	454	457	377	401	373	390	353	336	331	229

Waste group	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Municipal solid waste	1095	1033	885	685	451	318	78	19	16	26	16
Municipal sludge (d.m.)	3	2	3	3	2	5	1	0.2	0.1	0.1	0
Municipal sludge (wet m.)	22	23	22	22	17	14	7	3	2	2	3
Industrial sludge (d.m.)	26	27	32	32	19	7	3	4	3	2	1
Industrial sludge (wet m.)	82	78	96	94	42	20	10	10	8	12	21
Industrial solid waste	3135	3202	3227	3019	2947	2907	2862	2688	2626	2469	2622
Constr. and demol. waste	349	240	244	192	182	163	102	112	116	299	101

Table 6.5 Additional background data (Finland's NIR, 2017)

Description	Value	Unit
Waste generation rate	1.39	kg/capita/day
Fraction of MSW disposed to SWDS	32	%

Particle emissions

Particle emissions are calculated using the default emission factors from the EMEP/EEA Emission Inventory Guidebook 2019 and landfilled waste amounts (municipal and industrial solid waste and construction and demolition waste) and are presented in Table 6.6.

Table 6.6 Calculated particle emissions from solid waste disposal on land.

Year	TSP (t)	PM_{10} (t)	$PM_{2.5}$ (t)	Year	TSP (t)	PM_{10} (t)	$PM_{2.5}$ (t)
1990	2.6	1.2	0.2	2006	3.0	1.4	0.2
1991	2.5	1.2	0.2	2007	1.9	0.9	0.1
1992	2.2	1.1	0.2	2008	2.1	1.0	0.2
1993	2.0	0.9	0.1	2009	2.0	1.0	0.1
1994	1.8	0.9	0.1	2010	1.8	0.9	0.1
1995	1.7	0.8	0.1	2011	1.8	0.8	0.1
1996	1.6	0.7	0.1	2012	1.9	0.9	0.1
1997	1.4	0.7	0.1	2013	1.7	0.8	0.1
1998	1.4	0.6	0.1	2014	1.6	0.7	0.1
1999	1.8	0.8	0.1	2015	1.4	0.7	0.1
2000	1.9	0.9	0.1	2016	1.2	0.6	0.1
2001	2.0	0.9	0.1	2017	1.1	0.5	0.1
2002	1.9	0.9	0.1	2018	1.1	0.5	0.1
2003	2.2	1.0	0.2	2019	1.1	0.5	0.1
2004	2.8	1.3	0.2	2020	1.0	0.5	0.1
2005	2.8	1.3	0.2				

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 7 of the IIR.

Source-specific QA/QC and verification

Normal statistical quality checking related to the assessment of the magnitude and trends has been carried out. The quality system is implied since the 2012 submission. At present, no verification has been carried out for the specific source-sector emissions.

Source-specific recalculations including changes made in response to the review process

2018

- Particle emissions were included in the inventory due to the recommendation from the 2017 NECD Review.

2020

- NMVOC 2017 were recalculated due to update in activity data (minor decrease in emissions)

Source-specific planned improvements

None.

6.3 Composting (NFR 5B1)

Changes in chapter	
February 2022	KS, JMP

Source category description

NH_3 emissions from composting are included in the category from year 1990 onwards. The shares of emissions for each air pollutant reported under the NFR category are presented in Table 6.7. The category is not a key category for NH_3.

Table 6.7 Contribution of Biological treatment of waste - Composting (NFR 5B1) to total emissions in 2020.

Pollutant	Emissions from composting	Total emissions	Unit	Share of total emissions %	% reported by the plants
NH_3	0.117	30.466	Gg	0.4	0

Emission trend

The NH_3 emission trend (Figure 6.2) from composting increased after the early 1990's due to the increased composting especially in semi-urban areas, which results from separate collection of organic waste.

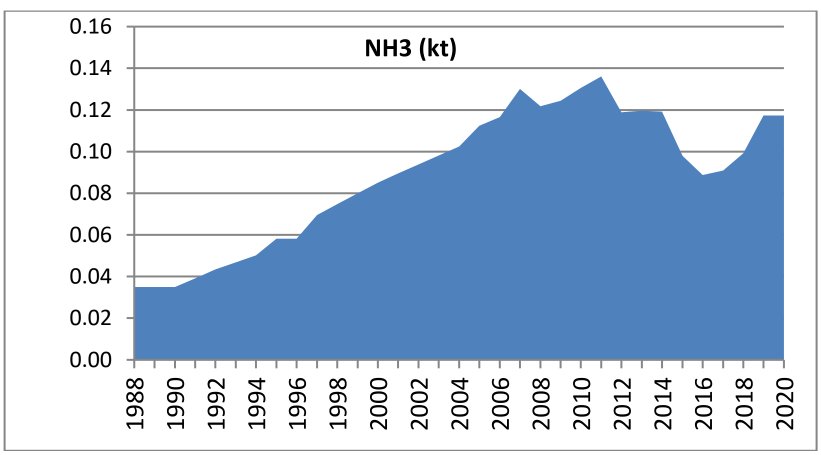


Figure 6.2 NH_3 emissions from composting 1980-2020

Methodological issues

NH_3 emissions

The emissions are calculated for the whole time series using the emission factor of 0.24 kg/Mg organic waste from the 2019 Guidebook. The activity data is presented Table 6.8 and the emissions in Table 6.9.

Table 6.8 Composted waste with auxiliary matter in 1990-2020 by subcategory (1000 t). (Finland's NIR, 2019)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Municipal solid waste	60	66	72	77	83	102	122	141	154	167
Municipal sludge (d.m.)	60	72	83	90	97	110	123	120	123	125
Industrial sludge (d.m.)	13	12	12	12	12	12	12	7	10	13
Industrial solid waste	12	13	14	16	17	18	19	21	24	28
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Municipal solid waste	180	190	199	209	218	233	232	289	284	281
Municipal sludge (d.m.)	128	131	133	136	138	159	160	151	155	142
Industrial sludge (d.m.)	15	18	21	23	26	32	36	42	33	33
Industrial solid waste	31	34	38	41	45	45	61	52	35	57
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Municipal solid waste	304	319	304	317	317	247	217	231	252	305
Municipal sludge (d.m.)	143	137	1121	128	120	113	95	102	99	113
Industrial sludge (d.m.)	38	33	22	22	25	25	17	12	13	20
Industrial solid waste	60	77	47	31	35	24	40	34	49	51
	2020									
Municipal solid waste	305									
Municipal sludge (d.m.)	113									
Industrial sludge (d.m.)	20									
Industrial solid waste	51									

Table 6.9 NH_3 emissions from composting 1990-2020

Year	NH_3 emission (kt)	Year	NH_3 emission (kt)	Year	NH_3 emission (kt)	Year	NH_3 emission (kt)
1990	0.035	2000	0.085	2010	0.131	2020	0.117
1991	0.039	2001	0.089	2011	0.136		
1992	0.043	2002	0.094	2012	0.119		
1993	0.047	2003	0.098	2013	0.120		
1994	0.050	2004	0.102	2014	0.119		
1995	0.058	2005	0.112	2015	0.098		
1996	0.066	2006	0.117	2016	0.089		
1997	0.070	2007	0.130	2017	0.091		
1998	0.075	2008	0.122	2018	0.099		
1999	0.080	2009	0.124	2019	0.117		

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 7 of the IIR to be submitted by 1st May 2020.

Source-specific QA/QC and verification

Normal statistical quality checking related to the assessment of the magnitude and trends has been carried out. The quality system is implied since the 2012 submission. At present, no verification has been carried out for the specific source-sector emissions.

Source-specific recalculations including changes made in response to the review process

2009
- NH_3 emissions from composting were included in the inventory.

2016
- NMVOC emissions were recalculated for whole time series (1990 onwards) to be consistent with UNFCCC reporting.

2018
- NMVOC emissions were excluded from the inventory, because no default method is presented in the Guidebook and due to the recommendation of the 2017 NECD Review.
- The mistake in the calculation of NH_3 emissions (incorrect amount of industrial solid waste in 2015, value was corrected from 35 to 24 kt) observed during the 2017 NECD Review was corrected. The impact of the mistake was far below the threshold of significance for a technical correction (2%).

2020
- For year 2017 the amounts of composted waste were updated resulting in minor increase in NH3 emissions. Due the lack of activity data the same amounts of composted waste were used for years 2017 and 2018.

2021
- Amounts of composted waste in 2018 were updated.

2022
- Amount of composted waste in 2019 were updated.

Source-specific planned improvements

None.

6.4 Anaerobic digestion at biogas facilities (NFR 5B2)

Changes in chapter	
February 2022	JG KS JMP

Source category description

The category covers biogas reactor plants at municipal and industrial wastewater treatment plants, municipal solid waste biogas plants, sewage sludge plants and as farm-scale plants.

At the beginning of 2021, most of all biomethane and biogas was produced in plants using sewage sludge and biowaste as feedstock. The total number of biogas plants was 79: 25 farm-scale plants, 9 at industrial wastewater treatment plants, 26 biogas plants for co-treatment of municipal solid waste and sewage sludge, and 19 sewage sludge plants (Finnish Biocycle and Biogas Association, 2022)

The shares of emissions for each air pollutant reported under the NFR category are presented in Table 6.10. The category is not a key category for NH_3.

Table 6.10 Contribution of Biological treatment of waste – Anaerobic digestion at biogas facilities (NFR 5B2) to total emissions in 2020.

Pollutant	Emissions	Total emissions	Unit	Share of total emissions %	% reported by the plants
NH_3	<0.1	30.466	Gg	<0.001	0

Emission trend

The NH_3 emission trend (Figure 6.3) from biogas facilities has increased strongly after the early 2000's due to the increase in anaerobic treatment of sewage sludge, and because anaerobic treatment of other organic wastes (municipal organic waste, food waste, animal-based sludge) became more common.

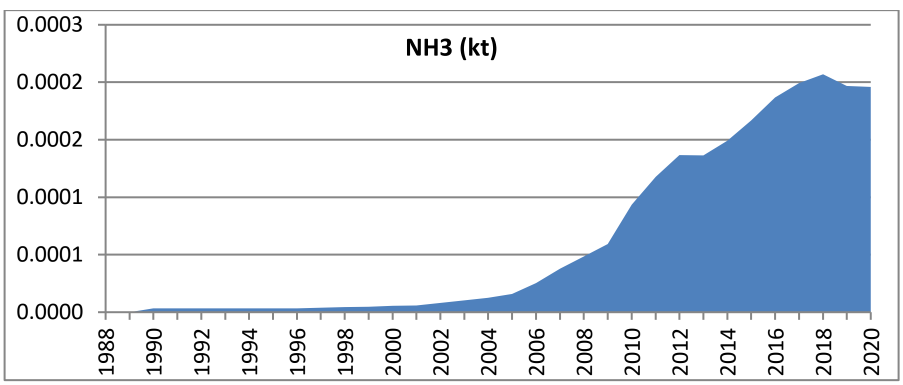


Figure 6.3 NH_3 emissions from biogas facilities 1990-2020

Methodological issues

NH_3 emissions

The emissions are calculated for the whole time series using the emission calculation methods described in the 2019 Guidebook. Calculation includes NH_3 emissions from the following sources:
1. storage of feedstock on the premises of the biogas facility;
2. storage of the digestate.

For 5.B.2, the Tier 2 approach is used.

The Tier 2 approach estimates the total emission, E_{NH3} (in kg NH_3 per year), from:

$$E_{\mathrm{NH3}} = AR_{\mathrm{feedstock}} \times \sum_{\mathrm{stages}} EF_{\mathrm{NH3\text{-}N,\,stage\ i}} \times 17/14$$

where $AR_{feedstock}$ is the total annual amount of N in feedstock, in kg a^{-1}; and $EF_{NH3\text{-}N}$, stage i is the NH_3-N EF for stage i (i is the pre-storage, and storage of digestate) related to the total N in feedstock (kg NH_3-N per kg total N).

Emission factor of 0.0009 kg NH_3-N per kg N in feedstock is used for pre-storage of feedstock, and emission factor of 0.0266 kg NH_3-N per kg N in feedstock is used for storage of digestate.

The digestion of manures is calculated separately from the digestion of other organic wastes and of energy crops, because the manure calculation in 5.B.2 is linked with the calculation of manure management (3.B) and manure application (3.D.a.2.a).

For digested manures, the TAN and total-N in manure (TAN_{sub} and N_{tot} respectively, kg a^{-1}) are:

$TAN_{sub} = m_{biogas\_slurry\_TAN} + m_{biogas\_solid\_TAN}$

$N_{sub} = m_{biogas\_slurry\_N} + m_{biogas\_solid\_N}$

where $m_{biogas\_slurry\_TAN}$, $m_{biogas\_solid\_TAN}$, $m_{biogas\_slurry\_N}$ and $m_{biogas\_solid\_N}$ are obtained from the manure management calculation module of the agricultural emission calculation system.

The TAN in digestate that is returned to agricultural emission calculation system is calculated using the equation:

$m_{dig\_TAN} = TAN_{sub} + f_{min} \times (N_{tot} - TAN_{sub}) – (E_{NH3} \times 14/17)$

where m_{dig_TAN}: TAN in digestate after storage in kg a^{-1}
f_{min}: relative share of organic N entering the digester that is mineralized to TAN in the digester in kg kg^{-1}
E_{NH3}: NH3 emitted in kg a^{-1}, calculated from total N

The total-N in digestate that is returned to agricultural emission calculation system is:

$m_{dig\_N} = N_{tot\_dig} – (E_{NH3} \times 14/17)$

Because no national data are available for f_{min}, a value of 0.32 for the N-mineralization of organic N in manures digested in biogas plants is used.

TAN flow for digestion is calculated separately for the different animal categories.

For digested energy crops and waste, $N_{tot,dig}$ in digestate after storage is calculated using equation:

$$N_{tot,dig} = N_{tot,sub} – (E_{NH3} \times 14/17)$$

$N_{tot,dig}$: Total amount of N in digestate after storage in kg a^{-1}
$N_{tot,sub}$: Total amount of N in the feedstock entering 5.B.2 in kg a^{-1}
E_{NH3}: Ammonia emitted during storage, in kg a^{-1}

The activity data is presented Table 6.11 and the emissions in Table 6.12.

Table 6.11 Anaerobically treated waste in 1990-2020 by subcategory (1000 t). (Finland's NIR, 2022 for the years 1990, 1995, 2000, 2005 and 2010-2020. For the other years, interpolated values are used)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Municipal solid waste	0	0	0	0	0	0	0	0	0	0
Municipal sludge (d.m.)	1.8	1.8	1.8	1.8	1.8	1.8	2.0	2.1	2.3	2.5
Industrial sludge (d.m.)	0	0	0	0	0	0	0	0	0	0
Industrial solid waste	0	0	0	0	0	0	0	0	0	0
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Municipal solid waste	3.8	5.0	15.0	25.0	35.0	42.4	47.0	54.0	61.0	68.0
Municipal sludge (d.m.)	2.6	2.6	2.7	2.7	2.8	2.9	7.0	11.0	15.0	19.0
Industrial sludge (d.m.)	0	0	0	0	0	0.5	0.6	0.6	0.7	0.7
Industrial solid waste	0	0	0	0	0	5.0	10.0	30.0	40.0	50.0
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Municipal solid waste	72.2	92.3	100.6	90.4	100.9	157.7	195.3	212.3	192.1	202.3
Municipal sludge (d.m.)	22.6	32.1	40.1	39.6	45.5	46.4	53.8	50.4	49.7	47.5
Industrial sludge (d.m.)	0.8	3.3	4.4	5.1	4.3	6.8	2.8	13.4	21.4	16.7
Industrial solid waste	66.1	61.7	64.4	75.9	77.7	79.5	102.2	112.3	128.5	117.8
	2020									
Municipal solid waste	202.3									
Municipal sludge (d.m.)	47.5									
Industrial sludge (d.m.)	16.7									
Industrial solid waste	117.8									

Table 6.12 NH_3 emissions from biogas facilities 1990-2020

Year	**NH_3 emission (t)**	**Year**	**NH_3 emission (t)**	**Year**	**NH_3 emission (t)**	**Year**	**NH_3 emission (t)**
1990	0.0034	2000	0.0057	2010	0.0936	2020	0.1959
1991	0.0034	2001	0.0059	2011	0.1178		
1992	0.0034	2002	0.0082	2012	0.1367		
1993	0.0034	2003	0.0102	2013	0.1364		
1994	0.0034	2004	0.0125	2014	0.1493		
1995	0.0034	2005	0.0157	2015	0.1666		
1996	0.0038	2006	0.0253	2016	0.1867		

1997	0.0039	2007	0.0378	2017	0.1992		
1998	0.0043	2008	0.0485	2018	0.2070		
1999	0.0047	2009	0.0592	2019	0.1968		

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 7 of the IIR.

Source-specific recalculations including changes made in response to the review process

2022

Calculation of NH3 emissions included as response to the TERT 2019/2020 recommendations.

Source-specific planned improvements

None.

6.5 Waste Incineration (NFR 5C)

Changes in chapter	
February 2022	KS JMP

Source category description

The amount of municipal waste at landfills is decreasing heavily. In 2012 the reduction was over one-quarter from the previous year and the same rate seems to be continuing in 2013 as well. Only 16.000 tonnes of municipal waste were deposited at landfills in 2018. For example, in 2008 the amount was still 1400000 tonnes. The co-combustion of waste with energy recovery is on the rise as can be seen from Table 6.4 and landfills for municipal waste have become history, as earlier in many other European countries.

The number of waste co-combusting with energy recovery has been rapidly increasing since 1994 due to implementation of the revised Waste Act, the revision of the Environmental Protection Act and the ban of organic waste to landfills since 2016 in addition to the rising cost of traditional fuels. In 2012, four new waste incineration plants started operation, in 2022 there are nine waste incineration plants in operation resulting in total capacity of 1.7 million t/a by the end of 2021. Typically, waste incineration occurs in peat and biomass firing boilers. The annual amount of waste co-incinerated is currently about 300,000 to 400,000 t/a. For more details, see IIR Part 2 Energy, chapter "Waste incineration".

All waste incineration in Finland includes energy recovery and the emissions are therefore reported under NFR 1A1a or NFR 1A2gviii.

Municipal waste incineration (NFR 5C1a)

Changes in chapter	
February 2022	KS, JMP

Source category description

All waste incineration in Finland includes energy recovery and the emissions are reported under NFR 1A1a or NFR 1A2gviii. The category is not a key category for any pollutants.

Methodological issues

SO_2, NO_x, NMVOC, particle and heavy metal emissions
SO_2, NO_x, NMVOC, particle and heavy metal emissions are reported by the plants according to the monitoring requirements in the environmental permits.

PCB and HCB

PCB and HCB emissions are calculated using Guidebook 2019 emission factor and activity data presented in Table 6.10. The emissions are reported under NFR 1A2gvii.

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 7 of the IIR.

Source-specific QA/QC and verification

Normal statistical quality checking related to the assessment of the magnitude and trends has been carried out. The quality system is implied in the calculation of 2010 emissions.

Source-specific recalculations including changes made in response to the review Process

2015
- Emissions before 2011 were corrected by removing double values: NFR 5C1a to NE (includes emissions from WWTPs), the emissions were allocated under 5D1.

2016
- Ammonia, PCDD/F and PAH-4 emissions in 5C1a were revised for whole time series. In previous submissions Finland has reported emissions from clinical waste incineration (NFR 5C1biii) although actually no incineration of clinical waste in hospital sites has occurred after the year 1993. At the end of 1993 the new Waste Act (1994) and Environment Protection Act came in force, where after clinical waste has been managed in larger toxic waste disposal plants or landfilled. In 2016 landfilling has been forbidden and all clinical waste has to be incinerated in waste incineration plants.
- HCB, PCB and PCP from waste incineration were included in the inventory.

2018
- HCB and PCB emissions were recalculated using Guidebook 2016 emission factors for the whole time series.
- The notation key for waste incineration NFR categories were changed to NO.

2020

- update of emission factors for HCB and PCB according to Guidebook 2019.

2021

- update of activity data from 2015-2018.

Source-specific planned improvements

None.

Industrial waste incineration including hazardous waste and sewage sludge (NFR 5C1b)

Changes in chapter	
February 2022	KS. JMP

Source category description

All waste incineration in Finland includes energy recovery. The emissions are reported under NFR 1A1a or NFR 1A2gviii, while the methodology to calculate the emissions is presented below.

Emission trend

Emission trends are presented in Figure 6.4.

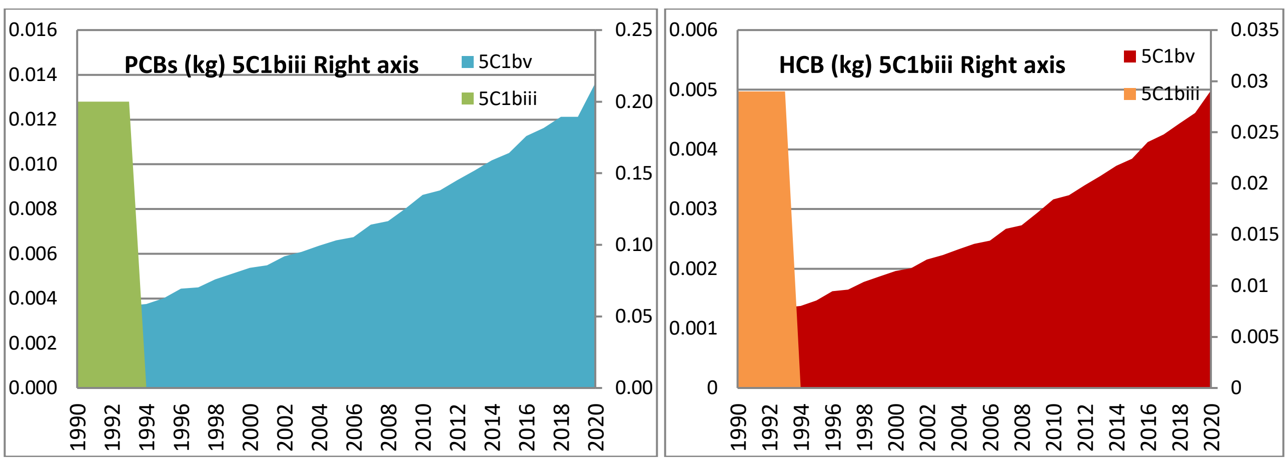


Figure 6.4 HCB and PCB emissions from industrial waste incineration

Methodological issues

SO_2, NO_x, NMVOC, Particle and heavy metal emissions

SO_2, NO_x, NMVOC, particle and heavy metal emissions are reported by the plants according to the monitoring requirements in the environmental permits in the YLVA database.

PCB and HCB emissions

PCB and HCB emissions are partly reported by the plants and have been completed with calculated emission data for those plants that do not report their emissions to the supervising authorities.

Amounts of incinerated industrial sludges are presented in Table 6.13 (source Statistics Finland for years 2004-2006 and for 2008-2020).

For years 1990-2003, 2007, and 2014 there is no official statistics available, that's why in the calculation it is assumed that 20% of the total incinerated industrial waste amounts were industrial sludges. When no official statistics available, waste amounts can be overestimated. According to an expert estimate (Espo, 2018) 10% of industrial sludges contains PCB for years 1990-2004, from 2005 onwards the percentage of PCBs containing sludges is 5 %. All PCBs containing sludges are incinerated in waste incineration plants. The accuracy and relevancy of the method will be further studied for the next submission and the use of emission factors derived from data reported by the plants will be studied.

Table 6.13 Amounts of incinerated industrial waste and industrial sludges (t) (Statistics Finland, 2021) Note that for years prior to 2015 the sludge amounts are expert estimates and are likely overestimates that will be checked for the next submissions.

	Incinerated sludge (t)	Incinerated sludge containing PCB/HCB (t)
1990	299288	29929
1991	299288	29929
1992	299288	29929
1993	299288	29929
1994	336699	33670
1995	374110	37411
1996	374110	37411
1997	406658	40666
1998	411521	41152
1999	341263	34126
2000	446687	44669
2001	432000	43200
2002	377975	37797
2003	302407	30241
2004	437200	43720
2005	631700	31585
2006	520400	26020
2007	549082	27454
2008	888000	44400
2009	516000	25800
2010	503000	25150
2011	470000	23500
2012	542000	27100
2013	690027	34501
2014	516065	25803

2015	85850	4293
2016	49619	2481
2017	63623	3181
2018	131526	6576
2019	87997	4400
2020	87997*	4400

**2019 values have been used*

<u>Revision of the calculation of HCB emissions</u>

HCB emissions were earlier calculated from the total volume of incinerated industrial waste. In the revised calculation carried out for the 2018 submission, HCB emissions are calculated for industrial sludges using the emission factor provided in the Guidebook 2016/2019 (Table 6.14).

The assumptions made for PCB containing sludges presented below are also assumed for HCB containing sludges and the calculation follows that of PCB emissions.

<u>Revision of the calculation of PCB emissions</u>

PCB emissions were earlier calculated from the total volume of incinerated industrial waste. In the revised time series PCB emissions are reported by the plants according to their environmental permit conditions for the years 1993-2006. For the remaining years the emissions are completed by calculated emissions using the EMEP EEA Guidebook 2016/2019 emission factors. The method to calculate emissions will be reconsidered for the next submission taking into account the possibility of using national EFs instead of Guidebook EFs.

Table 6.14 HCB and PCB emissions from industrial waste incineration

Year	HCB (kg)	PCB (kg)	Year	HCB (kg)	PCB (kg)
1990	0.135	0.141	2010	0.113	0.118
1991	0.135	0.141	2011	0.106	0.110
1992	0.135	0.141	2012	0.122	0.127
1993	0.140	0.141	2013	0.155	0.162
1994	0.012	0.158	2014	0.116	0.121
1995	0.080	0.176	2015	0.020	0.019
1996	0.095	0.176	2016	0.012	0.011
1997	0.012	0.191	2017	0.015	0.014
1998	0.200	0.193	2018	0.031	0.030
1999	0.055	0.160	2019	0.031	0.020
2000	0.329	0.210	2020	0.020	0.020
2001	0.218	0.203			
2002	0.283	0.178			
2003	0.208	0.142			
2004	0.117	0.205			
2005	0.219	0.148			
2006	0.105	0.122			
2007	0.124	0.129			
2008	0.200	0.209			
2009	0.116	0.121			

PCDD/F and PAH-4

The emissions are reported by the operators.

PCP

Emissions from hazardous waste incineration are based on data reported by the operators.

Emission factors for municipal waste incineration were derived at SYKE from emission data available from YLVA as a mean of the annual emission rates at hazardous waste incineration facilities. The first emission factor (233.6 mg/t) is used for the years 1990-2001, except for the biggest incineration plant which improved its technology in 1994. The revised emission factor (4.5 mg/t) for this plant was used after 1994. The emission factor that is used for the other plants for the more recent years (2002-2011) is 67.4 mg/t, since the abatement techniques and limit values for waste incineration have been improved in the 2000's. The change in the emission factor results in large variations in the calculated PCP emissions but the use of the same emission factor throughout the whole time series would either underestimate the emissions in the early 1990's or overestimate emissions in the recent years.

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 7 of the IIR.

Source-specific QA/QC and verification

Normal statistical quality checking related to the assessment of the magnitude and trends has been carried out. The quality system is implied in the calculation of 2010 emissions.

Source-specific recalculations including changes made in response to the review Process

2018

- HCB and PCB emissions recalculation using Guidebook 2016 methods

2021

- update of activity data prior to 2015, the earlier years are expert estimates

2022

- update of activity data for 2019

Source-specific planned improvements

Not scheduled

- The possibility to develop national emission factors for the calculation of HCB and PCB emissions will be further studied.

Clinical waste incineration (NFR 5C1biii)

Changes in chapter	
March 2021	KS. JMP

Source category description

Clinical waste incineration occurred in Finland until 1994, where after clinical waste incineration units were closed down. Thereafter was treated in a large toxic waste disposal plant or landfilled. From 2016 onwards clinical waste has been co-combusted in energy production plants. Thus, emissions prior to 1994 are reported under NFR 5C1biii and from the year 1994 onwards under NFR 1A1a or 1A2gviii.

The allocation of emissions was changed in the 2018 submission because all waste incineration in Finland has included energy recovery after the year 1993. This is due to the implementation of the 1994 Waste Act and the revised Environmental Protection Act, which came into force and resulted in a change also regarding clinical waste management. According to the legislation clinical waste had to be managed in larger toxic waste disposal plants or landfilled, and in 2016 landfilling was also forbidden.

The category is not a key category for any pollutants.

Methodological issues

Activity data

Activity data is an assumption based on an expert estimate (SYKE/Merilehto Kirsi, 2000 Table 6.15 above).

Table 6.15. Volume of incinerated clinical waste since 1990 (expert estimate, Merilehto 2000)

Year	Waste amount
1990	10 000 t
1991	10 000 t
1992	10 000 t
1993	10 000 t

Heavy metals

Heavy metals emissions from 1990-1993 are reported by the plants according to the monitoring requirements in the environmental permits. When no plant specific data is available, the emissions have been estimated.

POP compounds

PCDD/F, PAH-4, HCB and PCB emissions for the years 1990-1993 are calculated with the following emission factors, which are assumed to be more suitable for the Finnish conditions in the early 1990s than the Guidebook EFs. The EFs in the Guidebook are presented in the brackets.

PCDD/F	7 µg I-TEQ /t	(SYKE, 2001)	(GB16 40 mg I-TEQ/Mg)
PAH-4	20 mg/t	(EEA, 2002)	(GB16 0.04 mg/Mg)
HCB	2.9 mg/t	(Bailey, 2001)	(GB16 0.1 g/Mg)
PCB	20 mg/t		(GB 2016)

Emissions from clinical waste incineration 1990-1993 are presented in Table 6.16

Table 6.16 HCB, PCB, PCCD/Fs and PAH emissions from clinical waste incineration 1990-1993

Year	HCB (kg)	PCB (kg)	PCDD/F (ug I-TEQ)	PAH-4
1990	0.029	0.2	0.07	0.2
1991	0.029	0.2	0.07	0.2
1992	0.029	0.2	0.07	0.2
1993	0.029	0.2	0.07	0.2
Year	**B(a)P (kg)**	**B(b)F (kg)**	**B(k)F (kg)**	**I(1,2,3-cd)P (kg)**
1990	0.05	0.05	0.05	0.05
1991	0.05	0.05	0.05	0.05
1992	0.05	0.05	0.05	0.05
1993	0.05	0.05	0.05	0.05

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 7 of the IIR.

Source-specific QA/QC and verification

Normal statistical quality checking related to the assessment of the magnitude and trends has been carried out. The quality system is implied since the 2012 submission.

Source-specific recalculations including changes made in response to the review Process

2016

- Emissions from year 1994 onwards were included in NFR 5Ca1. In the 1990-2015 submissions emissions from clinical waste incineration (NFR 5C1 biii) were erroneously reported although no incineration of clinical waste occurred at hospital sites after the year 1993.

2018

- The notation key was changed to "NO" from 1994 onwards

Source-specific planned improvements

None.

Sewage sludge incineration (NFR 5C1biv)

No sewage sludge incineration occurs in the country.

Cremation (NFR 5C1bv)

Changes in chapter	
February 2022	KS

Source category description and explanation of emission trends

Emissions from cremation are calculated from 1990 onwards. The shares of emissions for each pollutant reported under the NFR category are presented in Table 6.17.

Cremation is a key category for mercury emissions according to the level and trend (Approach 1). NOx, NMVOC, SO_x are reported under 1A1a/1A2gviii

Table 6.17 Contribution of Cremation (NFR 5C1bv) to total emissions in 2020.

Pollutant	Tier	Emissions from cremation	Total emissions	Unit	Share of total emissions %	% reported by the plants
$PM_{2.5}$	T1	0.001	14.062	Gg	<0.1	0
PM_{10}	T1	0.001	26.564	Gg	<0.1	0
TSP	T1	0.001	39.486	Gg	<0.1	0
BC	T1	0.001	3.182	Gg	<0.1	0
Pb	T1	0.001	11.636	Mg	<0.1	0
Cd	T1	<0.001	0.7	Mg	<0.1	0
Hg	T2/T3	0.022	0.538	Mg	4.0	0
As	T1	<0.001	1.993	Mg	<0.1	0
Cr	T1	<0.001	13.893	Mg	<0.1	0
Cu	T1	<0.001	37.559	Mg	<0.1	0
Ni	T1	<0.001	9.677	Mg	<0.1	0
Se	T1	<0.001	0.358	Mg	0.2	0
Zn	T1	0.005	117.015	Mg	<0.1	0
PCDD/F	T1	<0.001	9.31	g I-Teq	<0.1	0
PAHs	T1	0.001	18.239	Mg	<0.1	0
HCB	T1	0.005	21.163	kg	<0.1	0
PCBs	T1	0.014	20.176	kg	<0.1	0

Emission trends

Cremation was not common in Finland in the 1990s and the number of cremations has gradually been increasing only since the beginning of the 2000s (Figure 6.5). Due to the low number of cremations, the first abatement technique (activated carbon filters) in a crematorium was installed first in 2013. Since 2020 activated carbon filters are used in seven out of the thirteen existing crematoria, while there is no abatement technique in the rest of the crematoria. The numbers of cremations each year in each of these 13 crematoria are available from the association of Finnish Congregations.

Emission trends are presented in Figure 6.5.

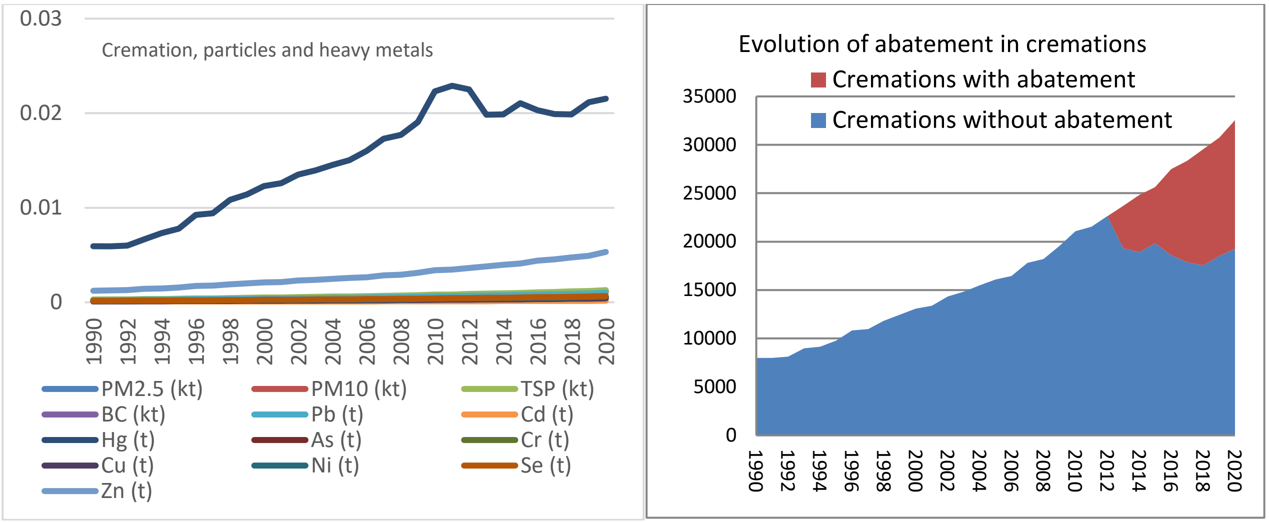


Figure 6.5 Emissions from Cremation

Methodological issues

Mercury emissions from crematoria

The use of amalgam in dental fillings has been low before the 1950s in Finland and then it has decreased again since the early 2000s to almost zero today, being in 2013 only 3% of all fillings. In 2018 a ban of amalgam was stipulated for persons of 15 years old or younger as well as for pregnant women. Most amalgam fillings in teeth have those born in 1940-1950, i.e. those currently older than 65 years.

In the calculation, the population numbers from 1990 have been divided into 3 groups: those older than 65 years, those 15-64 years and those younger than 15 years. For these three groups, the factors of 1, 0.5 and 0 have been used to quantify the cremations including amalgam tooth fillings: all in the age group >65 years, half of the age group 15-64 years and none in the age group <15 yrs. This may still lead into an overestimate due to missing teeth etc. but is a considerably smaller overestimation than using only the Tier 1 emission factor for all cremations.

The emission factor of 1.48 g/cremation (without abatement from Guidebook 2019) has been used for crematoria without abatement technique and the country specific emission factor of 0.59 g Hg/cremation for those cremations in crematoria with activated carbon filters. The country specific emission factor is based on Swedish and Finnish emission measurements, which result in concentrations below 0.1 mg/m^3(n), the removal efficiency of the activated carbon filters being 96-99.5%. Mercury emissions are presented in Table 6.19.

Activity data

The number of incinerated corpses is received from the Finnish Congregations (Finnish Congregations, 2021) by each crematoria, and out of these an annual share is calculated from cremations in crematoria with abatement and those without abatement (Table 6.18 and Figure 6.5).

Table 6.18. Cremations per year and annual shares with/without abatement (activated carbon)

	All	Without abatement	With abatement	Share abated		All	Without abatement	With abatement	Share abated
1990	8000	8000	0	0	2006	16459	16459	0	0
1991	8000	8000	0	0	2007	17796	17796	0	0
1992	8121	8121	0	0	2008	18199	18199	0	0
1993	8986	8986	0	0	2009	19561	19561	0	0
1994	9163	9163	0	0	2010	21068	21068	0	0
1995	9774	9774	0	0	2011	21540	21540	0	0
1996	10823	10823	0	0	2012	22648	22648	0	0
1997	10977	10977	0	0	2013	23702	19345	4357	0.183824
1998	11834	11834	0	0	2014	24822	18900	5922	0.238579
1999	12466	12466	0	0	2015	25631	19839	5792	0.225976
2000	13084	13084	0	0	2016	27483	18600	8883	0.323218
2001	13391	13391	0	0	2017	28336	17877	10459	0.369106
2002	14354	14354	0	0	2018	29550	17539	12011	0.406464
2003	14847	14847	0	0	2019	30733	18504	12229	0.397911
2004	15508	15508	0	0	2020	32545	19249	13296	0.408542
2005	16108	16108	0	0					

Particles, POPs and heavy metals

All emissions are calculated with the 2019 Guidebook EFs.

Particle and heavy metal emissions from cremation are presented in Table 6.19 and POP emissions in Table 6.20.

Table 6.19 Particle and heavy metal emissions from cremation

Year	TSP (t)	PM_{10} (t)	$PM_{2.5}$ (t)	BC (t)	Hg(g)	Pb(g)	Cd (g)	As (g)	Cr(g)	Cu(g)	Ni(g)	Se(g)	Zn(g)
1990	0.293	0.264	0.264	0.132	5914	228	38	104	103	95	132	151	1218
1991	0.299	0.269	0.269	0.135	5913	233	39	106	105	97	135	154	1243
1992	0.313	0.282	0.282	0.141	6008	244	41	111	110	101	141	161	1300
1993	0.347	0.312	0.312	0.156	6654	270	45	122	122	112	156	178	1439
1994	0.353	0.318	0.318	0.159	7305	275	46	125	124	114	159	181	1467
1995	0.377	0.339	0.339	0.170	7800	294	49	133	133	121	169	193	1565
1996	0.417	0.376	0.376	0.188	9241	325	54	147	147	135	188	214	1733
1997	0.423	0.381	0.381	0.190	9398	330	55	149	149	136	190	217	1758
1998	0.456	0.411	0.411	0.205	10825	355	60	161	160	147	205	234	1895
1999	0.481	0.433	0.433	0.216	11402	374	63	170	169	155	216	247	1996
2000	0.505	0.454	0.454	0.227	12273	393	66	178	177	163	227	259	2095
2001	0.516	0.465	0.465	0.232	12579	402	67	182	182	166	232	265	2144
2002	0.553	0.498	0.498	0.249	13506	431	72	195	195	178	249	284	2298
2003	0.573	0.515	0.515	0.258	13946	446	75	202	201	185	257	294	2377
2004	0.598	0.538	0.538	0.269	14510	466	78	211	210	193	269	307	2483
2005	0.621	0.559	0.559	0.279	15033	484	81	219	218	200	279	319	2579
2006	0.635	0.571	0.571	0.286	16000	494	83	224	223	205	285	326	2635
2007	0.686	0.618	0.618	0.309	17300	534	90	242	241	221	308	352	2849
2008	0.702	0.632	0.632	0.316	17692	547	92	248	247	226	315	360	2914
2009	0.754	0.679	0.679	0.339	19074	587	98	266	265	243	339	387	3132
2010	0.812	0.731	0.731	0.366	22323	633	106	287	286	262	365	417	3373
2011	0.831	0.747	0.747	0.374	22898	647	108	293	292	268	373	426	3449
2012	0.873	0.786	0.786	0.393	22525	680	114	308	307	282	392	448	3626
2013	0.914	0.822	0.822	0.411	19832	712	119	323	321	295	411	469	3795

2014	0.957	0.861	0.861	0.431	19867	745	125	338	337	309	430	491	3974
2015	0.988	0.889	0.889	0.445	21066	770	129	349	348	319	444	507	4104
2016	1.060	0.954	0.954	0.477	20318	825	138	374	373	342	476	544	4401
2017	1.093	0.983	0.983	0.492	19888	851	143	386	384	352	491	560	4537
2018	1.139	1.025	1.025	0.513	19886	887	149	402	401	367	512	585	4732
2019	1.185	1.066	1.066	0.533	21143	923	155	418	417	382	533	608	4921
2020	1.282	1.154	1.154	0.249	21545	998	167	452	451	413	576	658	5323

Table 6.20 POP emissions from cremation

Year	HCB (kg)	PCB (kg)	PCDD/F (g I-TEQ)	B(a)P (kg)	B(b)F (kg)	B(k)F (kg)	I(1,2,3-cd)P (kg)
1990	0.001	0.003	0.00021	0.10	0.05	0.05	0.05
1991	0.001	0.003	0.00021	0.10	0.06	0.05	0.05
1992	0.001	0.003	0.00022	0.11	0.06	0.05	0.06
1993	0.001	0.004	0.00024	0.12	0.06	0.06	0.06
1994	0.001	0.004	0.00025	0.12	0.07	0.06	0.06
1995	0.001	0.004	0.00026	0.13	0.07	0.06	0.07
1996	0.002	0.004	0.00029	0.14	0.08	0.07	0.08
1997	0.002	0.005	0.00030	0.14	0.08	0.07	0.08
1998	0.002	0.005	0.00032	0.16	0.09	0.08	0.08
1999	0.002	0.005	0.00034	0.16	0.09	0.08	0.09
2000	0.002	0.005	0.00035	0.17	0.09	0.08	0.09
2001	0.002	0.005	0.00036	0.18	0.10	0.09	0.09
2002	0.002	0.006	0.00039	0.19	0.10	0.09	0.10
2003	0.002	0.006	0.00040	0.20	0.11	0.10	0.10
2004	0.002	0.006	0.00042	0.20	0.11	0.10	0.11
2005	0.002	0.007	0.00043	0.21	0.12	0.10	0.11
2006	0.002	0.007	0.00044	0.22	0.12	0.11	0.12
2007	0.003	0.007	0.00048	0.23	0.13	0.11	0.12
2008	0.003	0.007	0.00049	0.24	0.13	0.12	0.13
2009	0.003	0.008	0.00053	0.26	0.14	0.13	0.14
2010	0.003	0.009	0.00057	0.28	0.15	0.14	0.15
2011	0.003	0.009	0.00058	0.28	0.16	0.14	0.15
2012	0.003	0.009	0.00061	0.30	0.16	0.15	0.16
2013	0.004	0.010	0.00064	0.31	0.17	0.15	0.17
2014	0.004	0.010	0.00067	0.33	0.18	0.16	0.17
2015	0.004	0.011	0.00069	0.34	0.18	0.17	0.18
2016	0.004	0.011	0.00074	0.36	0.20	0.18	0.19
2017	0.004	0.011	0.00077	0.37	0.20	0.18	0.20
2018	0.004	0.012	0.00079	0.39	0.21	0.19	0.20
2019	0.005	0.013	0.00083	0.41	0.22	0.20	0.21
2020	0.005	0.014	0.00090	0.44	0.24	0.21	0.23

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 7 of the IIR.

Source-specific QA/QC and verification

Normal statistical quality checking related to the assessment of the magnitude and trends has been carried out. The quality system is implied in the calculation of 2014 emissions.

Source-specific recalculations including changes made in response to the review Process

2013

- Inclusion of heavy metal emissions

2017

- The method was revised to the emission factors from the 2013 Guidebook to 2016 for the whole time series.

2020

- A country-specific method for calculation of Hg emissions was developed.

2021

- Incorrect Hg calculation file used in 2020 reporting has been revised for whole time series.

Source-specific planned improvements

None

Other waste incineration (NFR 5C1bvi)

No “other” waste incineration occurs in the country.

Open burning of waste (NFR 5C2)

Source category description

Incineration in households is forbidden according to the Environmental Protection Act and therefore no emissions are expected from this category.

On the request of the 2020 TERT we calculated the emission levels that would result from open burning of garden waste. Household and other “real” waste is not burned in Finland and forest residues are collected to industry or household energy purposes or left in the forest to improve soil or diversity of species. Using EFs in Table 3.3 of the 2019 Guidebook we conclude that the emissions would be below 0.0001% of national totals for all pollutants and thus insignificant.

From several national reports on household waste published in 2004-2019 we conclude that open burning of garden waste is happening occasionally and seasonally in the sparsely populated areas in small amounts as explained below. The amount of garden waste is estimated as 10 kg/inhabitant/year, while the population in sparsely populated areas is about half a million, half of these inhabitants burn garden waste occasionally and the amount that then is burned is 0.1% of the amount of garden waste. Instead of burning, twigs and branches are mostly composted, chipped, used as soil enrichment/building and in more densely populated areas mainly brought to recycling facilities for composting. Twigs and branches that are of sensible size to burn are preferably combusted as fuel in small combustion equipment as almost all dwelling houses, especially in the sparsely populated areas, have these equipment.

In Finland open burning of waste is forbidden and the offender will be fined as there are strict municipal orders about this. Everywhere in the country, also in sparsely populated areas, you are not allowed to cause nuisance to neighbours or danger of fire and you are fully responsible of any damage caused. In the sparsely populated areas, taking into account all above, it is possible to burn small amounts of dry twigs and branches on your own land. You can only burn in small batches similar to small campfires during the light time of the day and you need to have fire-fighting equipment and arrange guarding of the embers after the flames have died.

Source-specific recalculations including changes made in response to the review Process

2020

- This chapter (NFR 5C2) was accidentally removed when the IIR was thoroughly updated in the recalculation processes in 2018 and 2019 and is now returned to the IIR.

6.6 Wastewater Handling (NFR 5D)

Source category description

The emission sources cover municipal (domestic) and industrial wastewater handling plants, latrines and septic tanks. Emissions from wastewater treatment are declining since 1990 due to increasingly efficient treatment of wastewater which has also been implemented in sparsely populated areas, as well as a lower nitrogen burden released from industrial wastewaters into waterbodies.

Domestic wastewater handling (NFR 5D1)

Changes in chapter	
February 2022	KS, JMP

Source category description

NMVOC emissions from domestic wastewater handling and NH_3 emissions from latrines are reported under this category. The category is not a key category for any pollutants.

In Finland there are approximately 540 municipal wastewater treatment plants, in each of them wastewater from more than 50 people is treated (Finnish Water Utilities Association, FIWA, 2016).

The shares of emissions for each air pollutant reported under the NFR category are presented in Table 6.21.

Table 6.21 Contribution of Domestic wastewater handling (NFR 5D1) to total emissions in 2020.

Pollutant	tier	Emissions from domestic wastewater handling	Total emissions	Unit	Share of total emissions %	% reported by the plants
NMVOC	T1	0.009	84.587	Gg	<0.1	0
NH_3	T2	0.384	30.466	Gg	1.3	1.2

The same NMVOC emissions that are reported under the UNECE CLRTAP and the EU NECD are also reported under the UNFCCC, thus the activity data and methods used in the calculations are the same.

Emission trends

The emission trends are presented in Figure 6.6. The increase in NH_3 emissions since 2016 is due to the start of a new WWTP.

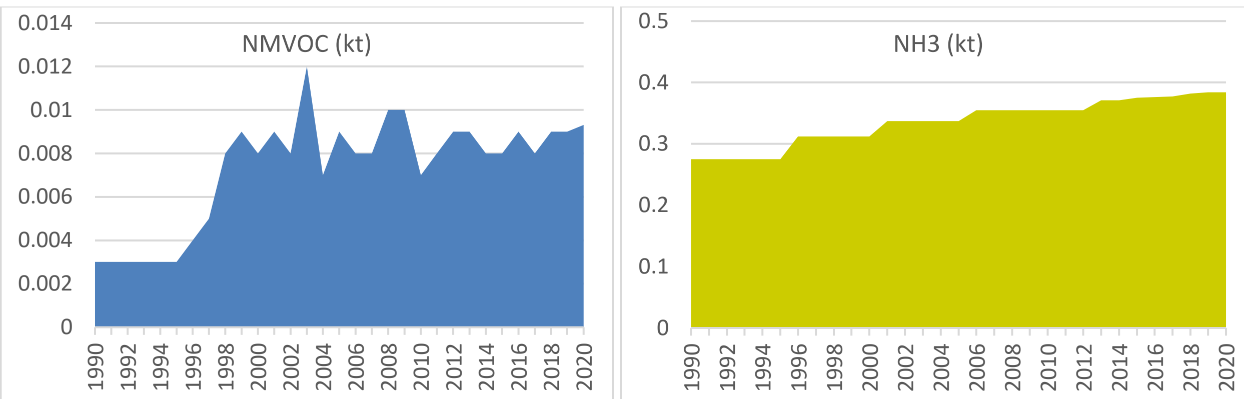


Figure 6.6 NMVOC and NH_3 emissions from municipal and domestic wastewater handling

Methodological issues

Domestic wastewater treatment

NMVOC emissions

NMVOC emissions are calculated using the method Guidebook 2019 (Table 6.24). Activity data is taken from YLVA database as presented in Table 6.22. For the years 2018, 2019 and 2020 same values have been used as reported in 2017 due to the lack of data in the YLVA database. Activity data for years 2018,2019 and 2020 will be updated in the next submissions.

NH_3 emissions

NH_3 emissions from domestic wastewater treatment are reported by the plants (Table 6.24). There is no methodology for estimating NH_3 emissions in the Guidebook.

Table 6.22 Handled domestic wastewater 1990-2020 (1000 m^3).

Year	handled domestic wastewater (1000 m^3)	Year	handled domestic wastewater (1000 m^3)
1990	213801	2010	510019
1991	200757	2011	569107
1992	196439	2012	618240
1993	168243	2013	539609
1994	177414	2014	512343
1995	281343	2015	566967
1996	352501	2016	513002
1997	519530	2017	620757
1998	584699	2018	620757
1999	538664	2019	620757
2000	575409	2020	620757
2001	552574		
2002	790886		
2003	475846		
2004	567214		
2005	550628		
2006	527119		
2007	643100		
2008	690266		
2009	494373		

Latrines

NH_3

NH_3 emissions from latrines are calculated according to Guidebook 2019 (Table 6.24).

Latrines are mainly used at summer cottages in Finland. It is assumed that latrines exist at 70% of summer cottages and are used by approximately 2 persons during the summer months, i.e. 4 months per year. The number of summer cottages and NH_3 emissions are presented in Table 6.23.

Table 6.23 Number of summer cottages in Finland 1990-2020 (Statistics Finland)

Year	Number of summer cottages	NH_3 (kt)	Year	Number of summer cottages	NH_3 (kt)
1980-84	251744	0.188	2014	500400	0.374
1985-89	251744	0.188	2015	501600	0.375
1990-94	367686	0.275	2016	502900	0.375
1995-99	416236	0.310	2017	507200	0.379
2000-2004	450569	0.336	2018	509800	0.381
2005-2011	474277	0.354	2019	511990	0.382
2012	496208	0.371	2020	508000	0.379
2013	496209	0.371			

Table 6.24 NMVOC and NH_3 emissions from NFR 5D1

	NMVOC (kt)	NH_3 (kt)
1990	0.003	0.275
1991	0.003	0.275
1992	0.003	0.275
1993	0.003	0.275
1994	0.003	0.275
1995	0.003	0.312
1996	0.004	0.312
1997	0.005	0.312

1998	0.008	0.312
1999	0.009	0.312
2000	0.008	0.337
2001	0.009	0.337
2002	0.008	0.337
2003	0.012	0.337
2004	0.007	0.337
2005	0.009	0.355
2006	0.008	0.355
2007	0.008	0.355
2008	0.010	0.355
2009	0.010	0.355
2010	0.007	0.355
2011	0.008	0.355
2012	0.009	0.371
2013	0.009	0.371
2014	0.008	0.375
2015	0.008	0.376
2016	0.009	0.377
2017	0.008	0.382
2018	0.009	0.384
2019	0.009	0.387
2020	0.009	0.384

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 7 of the IIR.

Source-specific QA/QC and verification

Normal statistical quality checking related to the assessment of the magnitude and trends has been carried out. The quality system is implied since the 2012 submission.

Source-specific recalculations including changes made in response to the review process

2016

- Previously NMVOC emissions from industrial and domestic wastewater handling were reported aggregated under NFR 5D3 Other wastewater handling and have since the 2016 submission been reported under NFRs 5D1 and 5D2.

2018

- The recommendation of the 2017 NECD Technical Review to revise the method to calculate NMVOC emissions could not be implemented because the wastewater volume data is not accurate enough to implement the method from the 2016 Guidebook. The current method is considered to be more accurate and is also consistent with the one used in the greenhouse gas reporting

2019

- NMVOC emissions are calculated as described Guidebook 2019.

2020

- Ammonia emissions from some point sources was accidentally excluded in the 2019 submission for the years 2012, 2014 and 2015. The missing NH_3 emissions have been included in the 2020 submission and increased slightly the emissions.

2021

- Reallocation of latrines from NFR 5E to NFR 5D1.

Source-specific planned improvements

Not scheduled

- Activity data 2018-2020 for domestic wastewater handling to be checked.

Industrial wastewater handling (NFR 5D2)

Changes in chapter	
February 2022	KS & JMP

Source category description

The shares of emissions for each air pollutant reported under the NFR category are presented in Table 6.25. The category is not a key category for any pollutants.

Table 6.25 Contribution of Industrial wastewater handling (NFR 5D2) to total emissions in 2020.

Pollutant	Tier	Emissions from industrial wastewater handling	Total emissions	Unit	Share of total emissions %	% reported by the plants
NMVOC	T1	0.018	84.587	Gg	<0.1	0

The NMVOC emissions reported under the UNECE CLRTAP and the EU NECD are also reported under the UNFCCC reporting and the activity data and methods used in the calculation are the same.

Emission trend

NMVOC emission trend is presented in Figure 6.7.

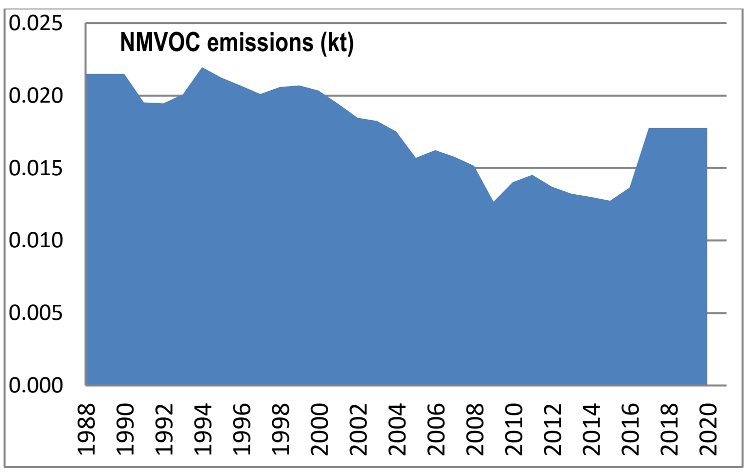


Figure 6.7 NMVOC emissions from industrial wastewater handling

Methodological issues

NMVOC emissions

NMVOC emissions are calculated using method presented in the EMEP/EEA Emission Inventory Guidebook 2019. Activity data is taken from YLVA database and presented in Table 6.26. For the years 2018, 2019 and 2020 the same value is used as reported in 2017 due the lack of activity data in YLVA database. Activity data for years 2018, 2019 and 2020 will be updated in next submissions.

Table 6.26 Handled industrial wastewater 1990-2020 (1000 m³).

Year	Handled industrial wastewater (1000 m³)	Year	Handled industrial wastewater (1000 m³)
1990	1433445	2010	936139
1991	1302372	2011	968823
1992	1297080	2012	913886
1993	1339249	2013	881691
1994	1463809	2014	868204
1995	1415457	2015	849596
1996	1378742	2016	910491
1997	1340104	2017	1184187
1998	1373581	2018	1184187
1999	1379977	2019	1184187
2000	1356726	2020	1184187
2001	1296868		
2002	1230824		
2003	1217227		
2004	1167849		
2005	1047229		
2006	1082900		
2007	1051384		
2008	1010498		
2009	845063		

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 7 of the IIR.

Source-specific QA/QC and verification

Normal statistical quality checking related to the assessment of the magnitude and trends has been carried out. The quality system is implied in the calculation of 2014 emissions.

Source-specific recalculations including changes made in response to the review process

2016

- Previously NMVOC emissions from industrial and domestic wastewater handling were reported aggregated under NFR 5D3 Other wastewater handling and have since the 2016 submission been reported under NFRs 5D1 and 5D2.

2018

- The recommendation of the 2017 NECD Technical Review to revise the method to calculate NMVOC emissions could not be implemented because the wastewater volume data is not accurate enough to implement the method from the 2016 Guidebook. The current method is considered to be more accurate and is also consistent with the one used in the greenhouse gas reporting

2019

- NMVOC emissions are calculated as described Guidebook 2019.

Source-specific planned improvements

- Check of AD for the years 2017-2020.

Other Wastewater handling (NFR 5D3)

Changes in chapter	
March 2021	KS & JMP

No “other” wastewater handling occurs in the country.

Source-specific recalculations including changes made in response to the review process

2016

- The allocation of NMVOC emissions under NFR categories was checked to be consistent with UNFCCC CRF categories since the 2016 submission. NMVOC emissions from wastewater handling previously reported under NFR 5D3 Other wastewater handling are now reported under NFRs 5D1 and 5D2 for the whole time series.

2018

- The notation key was changed from “NA” to “NO”

6.7 Other waste (NFR 5E)

Changes in chapter	
February 2022	KS & JMP

Source category description

NFR 5 E Other covers particle, PCDD/F and heavy metal emissions from house and car fires. The shares of emissions for each air pollutant reported under the NFR category are presented in Table 6.27.

Other waste is a key category for PCDD/F emissions according to the level and trend (Approach 1).

Table 6.27 Contribution of Other waste (NFR 5E) to total emissions in 2020.

Pollutant	Tier	Emissions from other waste	Total emissions	Unit	Share of total emissions %	% reported by the plants
$PM_{2.5}$	T2	0.095	14.062	Gg	0.7	0
PM_{10}	T2	0.095	26.564	Gg	0.4	0
TSP	T2	0.095	39.486	Gg	0.2	0
BC	T2	0.008	3.182	Gg	0.3	0
Pb	T2	<0.001	11.636	Mg	<0.1	0
Cd	T2	<0.001	0.7	Mg	<0.1	0
Hg	T2	<0.001	0.538	Mg	0,1	0
As	T2	<0.001	1.993	Mg	<0.1	0
Cr	T2	<0.001	13.893	Mg	<0.1	0
Cu	T2	0.002	37.559	Mg	<0.1	0
PCDD/ F	T2	0.98	9.31	g I-Teq	10.6	0

Emission trend

Emission trends are presented in Figure 6.8.

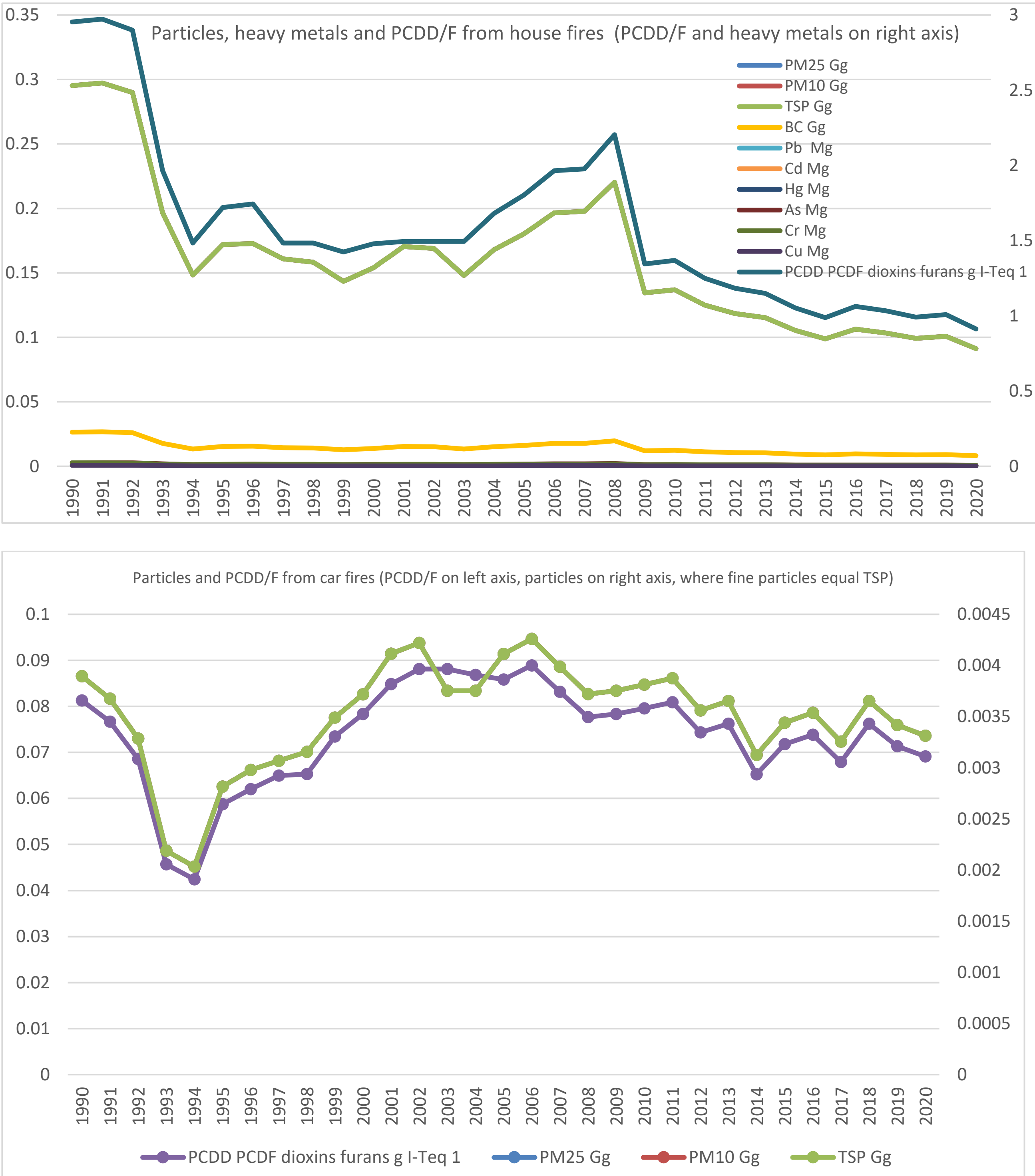


Figure 6.7 Emissions from car and house fires

Methodological issues

Car and house fires

Particles
Emissions from house and car fires are calculated using Tier 2 emission factors from the Guidebook 2019 with the EF of 2.3 kg/fire (TSP, PM_{10},$PM_{2.5}$)

Heavy metals

The emissions are calculated using Tier 2 EFs from Guidebook 2019 (Table 6.28).

Table 6.28 Emission factors for heavy metals and PCDD/F from house fires.

Pollutant	Unit	Emission factors for house fires (Guidebook 2019), tier 2			
		Detached houses	Undetached houses	Apartment buildings	Industrial buildings
TSP	kg/fire	143.82	61.62	43.78	27.23
PM10	kg/fire	143.82	61.62	43.78	27.23
PM2.5	kg/fire	143.82	61.62	43.78	27.23
Pb	g/fire	0.42	0.18	0.13	0.08
Cd	g/fire	0.85	0.36	0.26	0.16
Hg	g/fire	0.85	0.36	0.26	0.16
As	g/fire	1.35	0.58	0.41	0.25
Cr	g/fire	1.29	0.55	0.39	0.24
Cu	g/fire	2.99	1.28	0.91	0.57
PCDD/F	mg/fire	1.44	0.62	0.44	0.27

PCDD/F
The tier 2 emission factor of 0.048 mg/fire from Guidebook 2019 is used for car fires. For house fires, the tier 2 emission factor presented in Table 6.28 is used.

Activity data
Activity data for 1990-2020 is presented in Table 6.29.

For house fires it is assumed based on information from Rescue Services' Fire Statistics that
    26% of house fires are un-detached house fires
    4% detached house fires
    10% apartment building fires
    18% industrial building fires[1]

The Fire Statistics were changed in 2009 resulting in a lower number of house fires compared to the previous years.

Out of vehicle fires 68% are passenger car fires (Table 6.29, Rescue Services, 2002).

Table 6.29 Activity data: car and house fires (Rescue Services, 2022)

Year	Car fires	House fires	Year	Car fires	House fires
1990	1693 car fires	6 010 house fires	2006	1852 car fires	3 998 house fires
1991	1598 car fires	6 050 house fires	2007	1733 car fires	4 025 house fires
1992	1428 car fires	5 900 house fires	2008	1 618 car fires	4 485 house fires
1993	952 car fires	4 000 house fires	2009	1 632 car fires	2 736 house fires
1994	884 car fires	3 020 house fires	2010	1 658 car fires	2 786 house fires
1995	1224 car fires	3 500 house fires	2011	1 685 car fires	2 543 house fires
1996	1292 car fires	3 550 house fires	2012	2 277 car fires	2 413 house fires
1997	1353 car fires	3 020 house fires	2013	1 588 car fires	2 341 house fires
1998	1360 car fires	3 020 house fires	2014	1999 car fires	2144 house fires
1999	1530 car fires	2 900 house fires	2015	2 200 car fires	2010 house fires
2000	1632 car fires	3 010 house fires	2016	2 262 car fires	2164 house fires
2001	1768 car fires	3 040 house fires	2017	2 081 car fires	2106 house fires
2002	1836 car fires	3 040 house fires	2018	2 335 car fires	2018 house fires
2003	1836 car fires	3 040 house fires	2019	2 186 car fires	2053 house fires
2004	1809 car fires	3 420 house fires	2020	2 118 car fires	1857 house fires
2005	1788 car fires	3 670 house fires			

Emissions of particles, heavy metals and PCDD/F from Other Waste are presented in Tables 6.30 and 6.31.

Table 6.30 Particle, heavy metals and POP emissions from house fires

Year	TSP (Gg)	PM_{10} (Gg)	$PM_{2.5}$ (Gg)	As (kg)	Cd (kg)	Cu (kg)	Cr (kg)	Pb (kg)	Hg (kg)	PCDD/F (g I-TEQ)
1990	0.30	0.30	0.30	2.77	1.74	6.14	2.64	0.86	1.74	2.95
1991	0.30	0.30	0.30	2.78	1.76	6.18	2.66	0.87	1.76	2.97
1992	0.29	0.29	0.29	2.72	1.71	6.03	2.59	0.85	1.71	2.90
1993	0.20	0.20	0.20	1.84	1.16	4.09	1.76	0.58	1.16	1.97
1994	0.15	0.15	0.15	1.39	0.88	3.09	1.33	0.43	0.88	1.48
1995	0.17	0.17	0.17	1.61	1.02	3.58	1.54	0.50	1.02	1.72
1996	0.18	0.18	0.18	1.62	1.02	3.59	1.55	0.51	1.02	1.74
1997	0.16	0.16	0.16	1.51	0.95	3.34	1.44	0.47	0.95	1.48
1998	0.16	0.16	0.16	1.48	0.94	3.29	1.42	0.46	0.94	1.48
1999	0.15	0.15	0.15	1.34	0.85	2.98	1.28	0.42	0.85	1.42
2000	0.16	0.16	0.16	1.44	0.91	3.20	1.38	0.45	0.91	1.48
2001	0.17	0.17	0.17	1.60	1.01	3.54	1.52	0.50	1.01	1.49
2002	0.17	0.17	0.17	1.58	1.00	3.52	1.51	0.49	1.00	1.49
2003	0.15	0.15	0.15	1.39	0.87	3.08	1.32	0.43	0.87	1.49
2004	0.17	0.17	0.17	1.57	0.99	3.50	1.50	0.49	0.99	1.68
2005	0.18	0.18	0.18	1.69	1.07	3.75	1.61	0.53	1.07	1.80
2006	0.20	0.20	0.20	1.84	1.16	4.09	1.76	0.57	1.16	1.96
2007	0.20	0.20	0.20	1.85	1.17	4.11	1.77	0.58	1.17	1.98
2008	0.22	0.22	0.22	2.06	1.30	4.58	1.97	0.64	1.30	2.20
2009	0.14	0.14	0.14	1.26	0.79	2.80	1.20	0.39	0.79	1.34
2010	0.14	0.14	0.14	1.28	0.81	2.85	1.22	0.40	0.81	1.37
2011	0.13	0.13	0.13	1.17	0.74	2.60	1.12	0.37	0.74	1.25
2012	0.12	0.12	0.12	1.11	0.70	2.47	1.06	0.35	0.70	1.18
2013	0.12	0.12	0.12	1.08	0.68	2.39	1.03	0.34	0.68	1.15
2014	0.11	0.11	0.11	0.99	0.62	2.19	0.94	0.31	0.62	1.05
2015	0.10	0.10	0.10	0.93	0.58	2.05	0.88	0.29	0.58	0.99
2016	0.10	0.10	0.10	0.99	0.63	2.21	0.95	0.31	0.63	1.06

2017	0.10	0.10	0.10	0.97	0.61	2.15	0.93	0.30	0.61	1.03
2018	0.10	0.10	0.10	0.93	0.59	2.10	0.89	0.29	0.59	0.99
2019	0.10	0.10	0.10	0.94	0.60	2.10	0.90	0.30	0.60	1.01
2020	0.09	0.09	0.09	0.85	0.54	1.89	0.81	0.27	0.54	0.91

Table 6.31 Particle and POP emissions from car fires

Year	TSP (Gg)	PM_{10} (Gg)	$PM_{2.5}$ (Gg)	PCDD/PCDF (g I-TEQ)
1990	0.004	0.004	0.004	0.081
1991	0.004	0.004	0.004	0.077
1992	0.003	0.003	0.003	0.069
1993	0.002	0.002	0.002	0.046
1994	0.002	0.002	0.002	0.042
1995	0.003	0.003	0.003	0.059
1996	0.003	0.003	0.003	0.062
1997	0.003	0.003	0.003	0.065
1998	0.003	0.003	0.003	0.065
1999	0.003	0.003	0.003	0.073
2000	0.004	0.004	0.004	0.078
2001	0.004	0.004	0.004	0.085
2002	0.004	0.004	0.004	0.088
2003	0.004	0.004	0.004	0.088
2004	0.004	0.004	0.004	0.087
2005	0.004	0.004	0.004	0.086
2006	0.004	0.004	0.004	0.089
2007	0.004	0.004	0.004	0.083
2008	0.004	0.004	0.004	0.078
2009	0.004	0.004	0.004	0.078
2010	0.004	0.004	0.004	0.080
2011	0.004	0.004	0.004	0.081
2012	0.004	0.004	0.004	0.074
2013	0.004	0.004	0.004	0.076
2014	0.003	0.003	0.003	0.065
2015	0.003	0.003	0.003	0.072
2016	0.004	0.004	0.004	0.074
2017	0.003	0.003	0.003	0.068
2018	0.004	0.004	0.004	0.076
2019	0.003	0.003	0.003	0.071
2020	0.003	0.003	0.003	0.069

Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Annex 7 of the IIR.

Source-specific QA/QC and verification

Normal statistical quality checking related to the assessment of the magnitude and trends has been carried out. The quality system is implied in the calculation of 2010 emissions.

Source-specific recalculations including changes made in response to the review process

2009

- PCDD/F and PCB emissions from unintentional landfill fires were included.

2013

- NH_3 emissions from latrines were included.

2015

- Emissions from car and house fires were moved from NFR 2G (NFR09) to NFR 5E (NFR2014).

2016

- Emissions from car and house fires were recalculated as the result of correction of emission factors in Guidebook 2016. As described in Guidebook: *Personal contact with Kristin Aasestad has provided a correction of the units which are inaccurate in the text of Aasestad (2007). Previously EFs from Norwegian IIR has been used and the EF as a result of wrong unit has been 1000x to small. Black carbon emissions from house fires are calculated using emission factor 9% of PM2.5 (Aasestad, 2013).
- Emissions were reallocated to the NFR 5E from NFR 2G from the year 2014 emissions.
- Emissions from car, house and unintentional landfill fires are included in the inventory in the NFR 5E.

2017

- NH_3 emissions from latrines was reallocated to 5E, however, the change was done only for years 2014 and 2015 emissions.
- Heavy metal emissions from NFR 5E (house and car fires) were updated according to the Guidebook 2016.

2018

- No methodology is provided in the Guidebook to estimate emissions from landfill fires. The method used to calculate all emissions in the earlier submissions was considered to be uncertain and the emissions were removed to this submission.

2021

Reallocation of latrines from NFR 5E to NFR 5D1.

Source specific planned improvements

Possibilities to include HCB emissions from landfill fires to the inventory are studied.

9 OTHER NFR 6A

No emissions are occurring from other anthropogenic sources.