FINLAND's INFORMATIVE INVENTORY REPORT 2017

Air Pollutant Emissions 1980-2015

under the UNECE CLRTAP and the EU NECD

Part 4

Agriculture and Waste

Revised 28.04.2017 FINNISH ENVIRONMENT INSTITUTE

Centre for Sustainable Consumption and Production

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The documentation of the revised agricultural emissions calculation model was not available for the submission on 15.03.2017, although the results were included in the NFR tables and in the IIR. The documentation is included in this IIR revised 28.04.2017.

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AGRICULTURE (NFR 3)

The documentation of the resubmission of NFR tables 15 March 2017 is presented below based on the revised agricultural emissions calculation model, which was not ready for NFR submission on 15 February 2017.
The IIR submitted on 15.3.2017 included documentation of the original submission 15 February 2017 from the results of the older version of the agriculture calculation model.

7.1 Overview of the sector

Changes in chapter	
Update of emission figures	April 2017 JMP
Update of text	April 2017 KS & JMP
Change in methodology	Emission factors 2014-2015
Other (e.g. language, layout)	April 2017 KS

7.1.1 Agricultural activities in Finland

Agriculture in Finland is characterized by the northern climate and self-sufficiency in most major agricultural products. Its economic role is declining in terms of GDP and employment in primary production, but together with the food industry and forestry with which it is linked, it forms a significant part of the Finnish economy. The majority of farms and agricultural land in Finland lie between the 60th and 65th parallel, making it the only country in the world with a significant agricultural sector so far in the north. The percentage of farms concentrating on animal production increases towards the north and east.

Since 1990 there have been structural changes in agriculture, which have resulted in an increase in farm size and a decrease in the numbers of domestic livestock. The number of farms has steadily declined for the last decades. Between 2000 and 2012 their number fell from almost 80,000 to about 60,000 while the amount of arable land slightly increased to a total of almost 2.3 million hectares. As another example, the number of cattle was more than 33 per cent less in 2013 than in 1990. Agriculture employed 125,000 people in 2010 with a drop of 30 percent from 2000.

Although the decrease in the number of livestock cannot be seen in the development of ammonia emissions it is visible in CH_4 emissions from enteric fermentation and N_2O emissions from manure management. For ammonia, the specific ammonia emissions grow simultaneously with the decrease of animal numbers. Specifically this can be seen in the emissions from dairy cows. However, the emissions have not decreased in proportion to the drop in the number of livestock, because milk and meat output and emissions per animal have increased.

7.1.2 Emission trends

The Finnish inventory of air pollutants from agriculture includes emissions from animal husbandry, (including manure management, manure application and grazing), application of mineral fertilizers, harvesting, field preparation, storage and handling of agricultural crops, field burning of agricultural wastes, use of pesticides and sewage sludge application to soils (Table 5.32).

Table 5.32. Activities and emissions reported under NFR 3 Agriculture.

		Pollutants						Activities
NFR	SNAP	NH3	NOx	TSP	PM10	PM2.5	NMVOC	
3B1a	100501	x	x	x	x	x	x	Dairy cattle
3B1b	100502	x	x	x	x	x	x	Non-dairy cattle: including sukcler cows, bulls, calves and heifers
3B2	100505	x	x	x	x	x	x	Sheep with lambs
3B3	100503,	x	x	x	x	x	x	Swine, incl. fattening pigs, sows with piglets, veaned pigs (20-50
3B4 a	100514	NO	NO	NO	NO	NO	NO	Buffalo
3B4 d	100511	x	x	x	x	x	x	Goats with
3B4 e	100506	x	x	x	x	x	x	Horses and ponies
3B4 f	100512	NO	NO	NO	NO	NO	NO	Mules and asses

3B4 g i	100507	x	x	x	x	x	x	Laying hens
3B4 g ii	100508	x	x	x	x	x	x	Broilers, broiler hens
3B4 g iii	100509a	x	x	x	x	x	x	Turkeys
3B4 g iv	100509b	x	x	x	x	x	x	Other Poultry, incl. cockerels, broiler hens, chickens and other
3B4 h	100515,	x	x	x	x	x	x	Fur animals, reindeers

NFR	SNAP	Pollutants	Activities
3Da1	100101-	NH_3, NOx, TSP, PM_{10}, $PM_{2.5}$	Inorganic N fertilisers (includes uurea) ; Application of nitrogen fertilizers (NH_3),
3Da2a	100905	NH3 (calculated in 3B), NOx, NMVOC	Animal manure applied to soils
3Da2b	100906	NH_3,	Sewage sludge applied to soils
3Da2c	100907		Other organic fertilisers applied to soils
3Da3	100517	NH3 (calculated in 3B),NOx, NMVOC	Urine and dung deposited by grazing animals
3Da4	100207	-	Crop residues applied to soils
3Db	100208	-	Indirect emissions from managed soils
3Dc	100901-	TSP, PM_{10}, $PM_{2.5}$	Farm-level storage, handling and transport of agricultural products; Storage and
3Dd	101100	-	Off-farm storage, handling and transport of agricultural products
3De	100201-	NMVOC	Cultivated crops, crops
3Df	100601-	emission of spesific pestiside (HCB)	Use of pesticides
3F	100301-	NOx, CO, NMVOC, SOx, TSP, PM10,	Field burning of agricultural residues

Ammonia

Ammonia emissions are generated from manure management, application of nitrogen fertilizers, sewage sludge applied to soils and field burning of agricultural wastes. The total agricultural NH_3 emissions in 2015 were 31.8 Gg. out of which 18 Gg originated in agricultural sources, 9.8 Gg in fertilizer use and manure applied to soils, 0.9 kt in deposits by grazing, and 0.1 in field burning of agricultural wastes. The contribution of NFR sectors to ammonia emissions is presented in Figure 5.1.

Agricultural ammonia emissions have been decreased over the period of 1980–2015 (Figure 5.2 and Table 5.2) partly due to changes in the economic structure followed by an increase in the average farm size and a decrease in the number of small farms. Those changes resulted in the decrease of livestock numbers except for the number of horses that has increased in the recent years due to the increasing interest in equitation. In addition, the use of nitrogen fertilisers has been reduced while manure management has been improved due to measures taken by the farmers as a part of an agro-environmental program aiming to minimise nutrient loading to water courses.

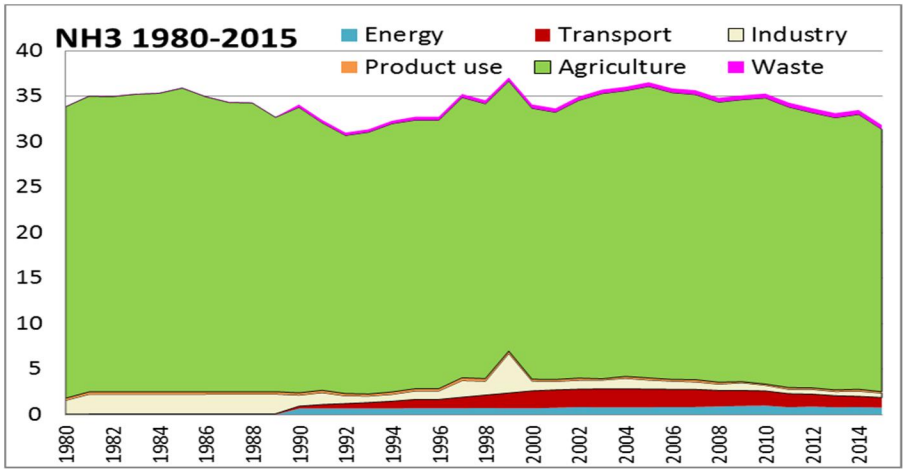


Figure 5.2. The contribution of NFR sectors to ammonia emissions 1980-2015.

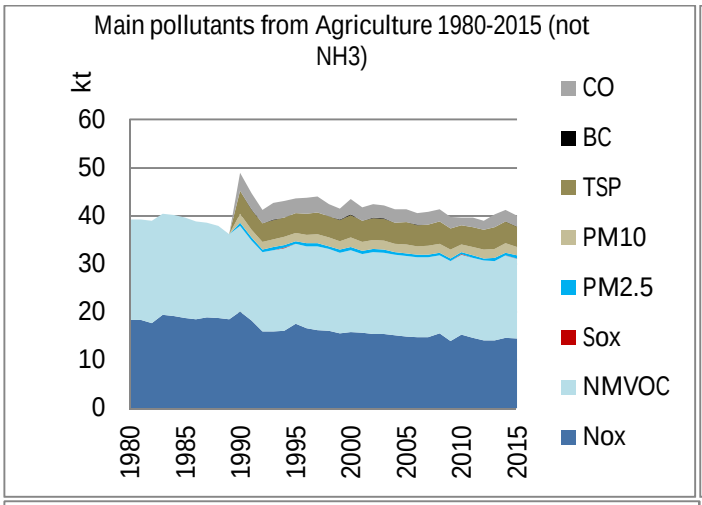
Table 5.33. Ammonia emissions from agricultural sources (Gg) 1980-2015.

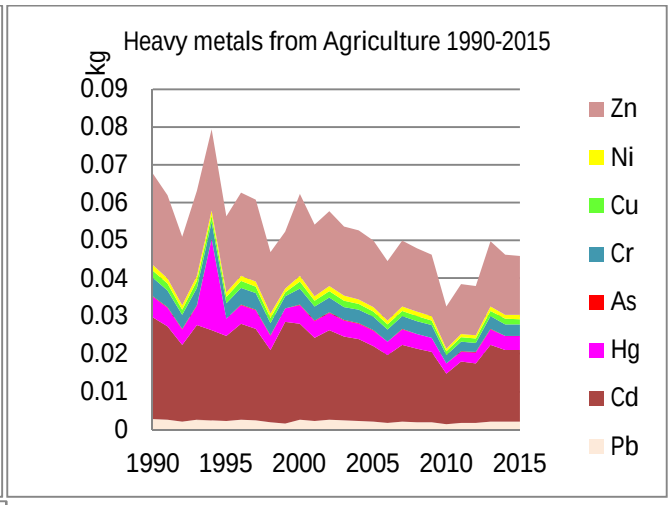
Year	NFR 3B	NFR 3D1a	NFR 3Da2a	NFR 3Da2b	NFR 3Da3	NFR 3F	Total
1980	18.9	3.35	8.34	NE	1.35	0.07	32.02
1981	19.2	3.34	8.50	NE	1.34	0.07	32.51
1982	19.9	3.14	8.07	NE	1.32	0.07	32.47
1983	19.7	3.67	7.95	NE	1.31	0.07	32.72
1984	19.7	3.60	8.11	NE	1.30	0.07	32.82
1985	20.0	3.48	8.62	NE	1.25	0.07	33.40
1986	19.8	3.45	7.94	NE	1.24	0.07	32.44
1987	19.1	3.62	7.83	NE	1.19	0.07	31.81
1988	18.7	3.65	8.23	NE	1.15	0.07	31.75
1989	17.4	3.65	7.90	NE	1.13	0.07	30.15

1990	17.7	4.05	8.43	0.060	1.05	0.11	31.38
1991	16.6	3.59	8.06	0.048	1.02	0.10	29.40
1992	16.4	2.90	7.96	0.042	0.99	0.08	28.37
1993	16.6	2.98	8.11	0.038	0.99	0.10	28.79
1994	17.0	3.00	8.31	0.056	0.98	0.10	29.49
1995	16.9	3.47	8.10	0.036	0.94	0.09	29.52
1996	17.4	3.18	8.26	0.042	0.95	0.10	29.94
1997	18.1	3.00	8.59	0.046	0.96	0.10	30.81
1998	17.7	3.01	8.49	0.016	0.94	0.07	30.21
1999	17.3	2.89	8.47	0.018	0.93	0.07	29.69
2000	17.2	2.97	8.55	0.014	0.93	0.10	29.79
2001	16.8	2.94	8.61	0.020	0.93	0.09	29.37
2002	17.6	2.85	9.01	0.017	0.94	0.09	30.52
2003	18.2	2.83	9.29	0.021	0.93	0.08	31.35
2004	18.2	2.74	9.42	0.012	0.94	0.08	31.39
2005	18.7	2.65	9.68	0.004	0.95	0.08	32.03
2006	18.4	2.63	9.50	0.004	0.97	0.07	31.52
2007	18.3	2.64	9.35	0.004	0.97	0.08	31.34
2008	17.8	2.86	9.10	0.007	0.98	0.08	30.78
2009	18.4	2.36	9.16	0.007	0.99	0.07	30.99
2010	18.5	2.68	9.20	0.009	1.00	0.05	31.45
2011	18.3	2.47	8.99	0.004	0.99	0.06	30.83
2012	18.1	2.32	8.80	0.007	0.95	0.06	30.25
2013	17.9	2.28	8.75	0.007	0.94	0.08	29.93
2014	17.9	2.40	8.87	0.007	0.94	0.07	30.21
2015	18.0	2.31	7.51	0.002	0.95	0.07	28.83

NO_x, CO, SO_x, NMVOC, particle, heavy metal and POP emissions

Agriculture is also a source of NO_x, CO, SO_x, NMVOC, particle, heavy metal and POP emissions (Figure 5.3).





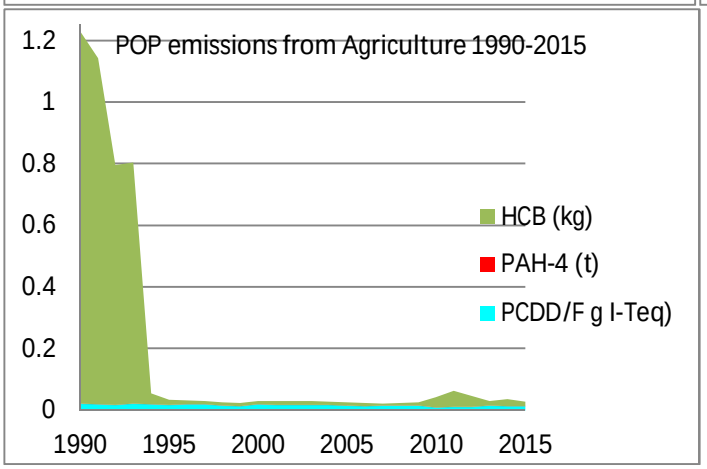


Figure 5.3 Emissions of main pollutants 1980-2015 and heavy metals and POPs 1990-2015 from agricultural sources

NMVOC

NMVOC emissions are generated in manure management, manure applied to soils, deposits during grazing, cultivated crops and field burning of agricultural waste. A summary of agricultural emissions is presented in Table 5.3.

Table 5.3 NMVOC emissions from agricultural sources (Gg) 1980-2015.

Year	NFR 3B	NFR 3Da2a	NFR 3Da3	NFR 3De	NFR 3F	Total
1980	16.04	3.55	0.16	1.14	NE	20.89
1981	16.08	3.57	0.16	1.13	NE	20.94
1982	16.35	3.62	0.16	1.14	NE	21.26
1983	16.12	3.56	0.15	1.14	NE	20.96
1984	16.12	3.61	0.15	1.13	NE	21.00
1985	16.10	3.60	0.14	1.07	NE	20.91
1986	15.64	3.52	0.14	1.06	NE	20.37
1987	15.06	3.41	0.14	1.07	NE	19.68
1988	14.58	3.31	0.13	1.04	NE	19.06
1989	13.41	3.08	0.12	1.14	NE	17.74
1990	13.27	3.10	0.10	1.17	0.25	17.89
1991	12.49	2.93	0.10	0.93	0.23	16.68
1992	12.40	2.89	0.09	0.92	0.19	16.48
1993	12.68	2.94	0.09	0.92	0.24	16.88
1994	12.96	3.01	0.09	0.92	0.23	17.21
1995	12.46	2.92	0.09	0.92	0.21	16.60
1996	12.72	2.96	0.08	0.99	0.22	16.97
1997	13.10	3.06	0.08	0.98	0.22	17.44
1998	12.77	3.01	0.08	1.02	0.15	17.04
1999	12.59	2.98	0.08	1.03	0.17	16.85
2000	12.65	3.02	0.08	1.04	0.21	17.00
2001	12.27	2.98	0.08	0.97	0.18	16.48
2002	12.60	3.08	0.08	1.06	0.17	16.99
2003	12.61	3.10	0.07	0.96	0.16	16.90
2004	12.48	3.09	0.07	0.91	0.16	16.73
2005	12.51	3.13	0.07	0.89	0.18	16.77
2006	12.49	3.05	0.07	0.85	0.16	16.62
2007	12.43	2.98	0.07	1.01	0.16	16.65
2008	12.14	2.87	0.07	0.99	0.17	16.23
2009	12.51	2.88	0.07	0.98	0.16	16.60
2010	12.82	2.90	0.07	0.81	0.10	16.69
2011	12.76	2.83	0.07	0.90	0.11	16.66
2012	12.68	2.78	0.07	0.93	0.11	16.55
2013	12.64	2.77	0.07	0.95	0.16	16.59
2014	12.99	3.00	0.07	0.90	0.14	17.09
2015	13.07	2.55	0.07	0.89	0.13	16.71

NOx

NOx emissions are generated in manure management, use of fertilizers, manure applied to soils, deposits during grazing and field burning of agricultural waste. A summary of agricultural emissions is presented in Table 5.4.

Table 5.4 NOx emissions from agricultural sources (Gg) 1980-2015.

Year	NFR 3B	NFR 3Da1	NFR 3Da2a	NFR 3Da3	NFR 3F	Total
1980	0.53	11.6	4.77	1.49		18.4
1981	0.53	11.6	4.83	1.48		18.4
1982	0.53	10.9	4.89	1.46		17.8
1983	0.54	12.7	4.82	1.45		19.5
1984	0.53	12.4	4.82	1.44		19.2
1985	0.53	12.0	4.77	1.39		18.7
1986	0.52	11.9	4.72	1.37		18.5
1987	0.50	12.5	4.58	1.33		18.9
1988	0.49	12.6	4.45	1.28		18.8
1989	0.45	12.6	4.20	1.24		18.5
1990	0.45	14.0	4.38	1.13	0.113	20.1
1991	0.42	12.4	4.15	1.08	0.103	18.2
1992	0.42	10.0	4.09	1.03	0.085	15.6
1993	0.43	10.3	4.13	1.04	0.106	16.0
1994	0.44	10.4	4.21	1.02	0.102	16.1

1995	0.43	12.0	4.10	0.96	0.094	17.6
1996	0.44	11.0	4.15	0.96	0.102	16.7
1997	0.45	10.4	4.29	0.96	0.101	16.2
1998	0.45	10.4	4.21	0.93	0.075	16.1
1999	0.44	10.0	4.15	0.92	0.071	15.6
2000	0.44	10.3	4.15	0.92	0.100	15.9
2001	0.42	10.2	4.09	0.90	0.087	15.7
2002	0.43	9.8	4.22	0.91	0.090	15.5
2003	0.43	9.8	4.29	0.90	0.084	15.5
2004	0.42	9.5	4.27	0.90	0.084	15.2
2005	0.42	9.2	4.34	0.90	0.083	14.9
2006	0.41	9.1	4.30	0.90	0.074	14.8
2007	0.40	9.1	4.29	0.89	0.080	14.8
2008	0.39	10.0	4.23	0.88	0.078	15.6
2009	0.40	8.3	4.33	0.88	0.076	14.0
2010	0.40	9.6	4.39	0.89	0.051	15.3
2011	0.40	9.0	4.35	0.88	0.060	14.7
2012	0.40	8.5	4.33	0.85	0.059	14.2
2013	0.40	8.5	4.29	0.84	0.080	14.1
2014	0.41	9.0	4.36	0.84	0.073	14.7
2015	0.41	8.8	4.40	0.85	0.071	14.5

CO, SO_x

Emissions originate from field burning of agricultural waste (see NFR 3F).

Particles

TSP, PM10, PM2.5 emissions are generated in animal husbandry, grain fields, storage and handling of agricultural crops and fertilizers. TSP, PM10, PM2.5 and BC emissions are generated in field burning of agricultural waste. (a table will be added to the next submission)

Heavy metals

Emissions are generated in field burning of agricultural waste (see NFR 3F).

POPs

The use of pesticides is a source of HCB emissions (see NFR 3Df) and field burning of agricultural waste is a source of PAH emissions (see NFR 3F).

Changes in chapter	
Update of emission figures	April 2017 JMP
Update of text	April 2017 JMP, KS
Changes in methodology	2009, 2011, 2013-2017
Recalculations	2016-2017
Other (e.g. language, layout)	April 2017 KS

7.2.1 Source category description

This sector covers management of manure from domestic livestock.

Figure 5.4 K. Inha: Finnish agriculture, series of photographs, 1899, photographed scenes of Finnish agricultural work for the World´s Fair (Exposition Universelle) in Paris in 1900.

Finland reports emissions from manure management of cattle (including dairy cows, suckler cows, heifers, bulls and calves), swine, horses, goats, sheep, poultry, fur animals and reindeer. Mules, asses, camels and buffalos are not farmed in Finland (Table 5.5).

Table 5.5. Animal categories in Finland

NFR	Animal category
3B1a	Cattle, dairy
3B1b	Cattle, non-dairy
3B2	Sheep
3B3	Swine
3B4a	Buffalo - not farmed in Finland
3B4d	Goats
3B4e	Horses
3B4f	Mules and asses - not farmed in Finland
3B4gi	Laying hens
3B4gii	Broilers
3B4giii	Turkeys
3B4giv	Other poultry - cockerels, broiler hens, chicken and other poultry
3B4h	Other - reindeer and fur animals

7.2.2 Methodological issues

The results of the revised calculation model for agricultural emissions were included in the 15 March 2017 NFR submission. Documentation of the revised method is presented below and in a separate document Grönroos et al 2017 (saved in the submission folder).

Calculation model for agricultural emissions

Since 1998, ammonia emissions originating from manure have been calculated by using the national nitrogen model, which is based on the nitrogen flow approach. In this approach, flow of total ammoniacal nitrogen (TAN) and total nitrogen (tot-N) are followed through the manure management system so that the more NH3 and other nitrogen compounds are emitted at the previous stage of the manure management system the less TAN and tot-N remain available for emissions later. The model includes also ammonia emission calculation for mineral N-fertilisers. The documentation of the previous calculation systems were published by Grönroos et al. in 1998 (in Finnish) and in 2009 (in English). Originally, the model was used only for ammonia emission modelling, but it was supplemented later with N2O and NO and N2 emission calculation.

The model was revised in 2016-2017 (Figure 5.5) and includes currently gaseous nitrogen emissions (N_2, NH_3, N_2O and NO) thus integrating the calculation of nitrogen emissions between the greenhouse gas and air pollutant emission inventories. It also enables reporting of emissions at the level of detail in the reporting guidelines of the UNECE CLRTAP and the UNFCCC.

The revision of the model included updating and expanding the model to meet the most recent requirements of the emission inventory guidelines of UNECE (EMEP/EEA 2016) and UNFCCC (IPCC 2006). The revision included change of the nitrogen flow approach to a entirely total ammoniacal nitrogen (TAN) based approach. In the previous model version, the approach was mainly based on the total nitrogen.

Nitrogen from bedding materials was also included into the calculation. In addition to the ammonia (NH_3) and direct and indirect nitrous oxide (N_2O) emissions (originating from manure management and managed soils), emissions of nitric oxide (NO) and di-nitrogen (N_2) from manure management are calculated, as well as NO emissions from application of manure and mineral fertilisers.

NMVOC emission calculation for manure management, manure applied to soils, urine and dung deposited by grazing animals and cultivated crops was added to the calculation system (see Table 5.6 and Chapter 2.2 in Grönroos et al., 2017). Further, the changes enabled the establishment of the Finnish normative manure system (see Luostarinen et al. 2017), which was built simultaneously with the revision of this model.

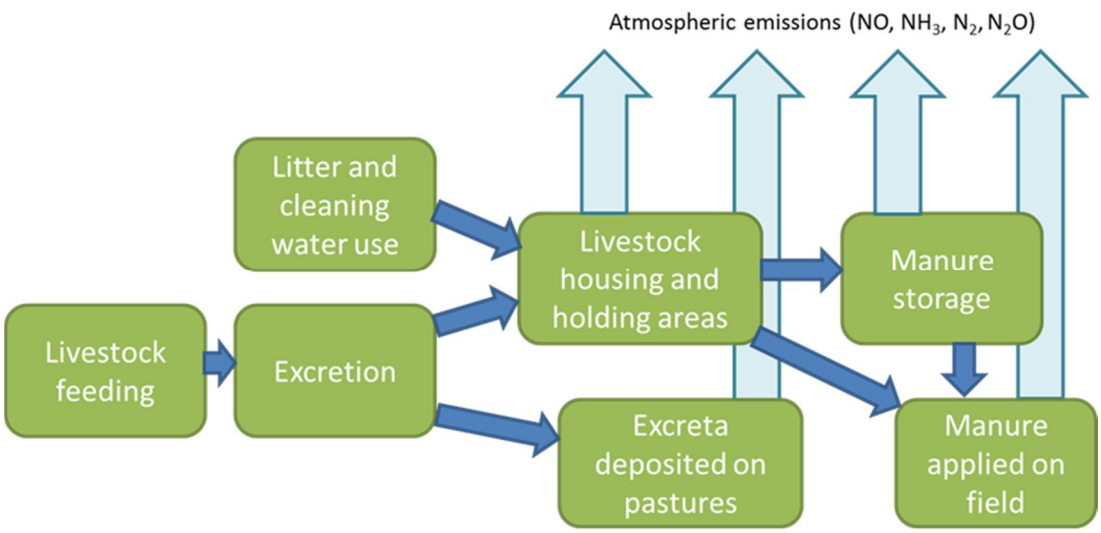


Figure 5.5 Revised calculation model for agriculture (Grönroos et al., 2017)

Table 5.6 Source categories and emissions included in the agricultural emission calculation system.

NFR	Category name	NH_3	NOx	N_2O direct	N_2O indirect	N_2	NMVOC
3B	Manure management (animal categories: see chapter 2.1.1.1)	x	x	x	x	x	x
3Da1	Inorganic N-fertilizers (includes also urea application)	x	x	x	x		x
3Da2a	Animal manure applied to soils	x		x	x		x
3Da3	Urine and dung deposited by grazing animals	x		x	x		x
3De	Cultivated crops						x

The model is updated yearly, a new reporting year is added every year and the previous years are updated when new information is available.

Basis of calculation

Calculation of the gaseous nitrogen emissions from manure management is based on the mass or nitrogen flow approach, as described in the previous Finnish ammonia and nitrous oxide emission calculation documentations (Grönroos et al. 1998; Grönroos et al. 2009), and in the UNECE and UNFCCC emission inventory guidebooks. In the method used, the pathways of nitrogen are followed starting from the nitrogen excretion of the livestock and ending at the application of manure to the fields (Figure 5.6). In each manure management stage the gaseous losses of nitrogen are calculated. The calculation is carried out per each animal category (Table 5.7.a and 5.7.b) and for each manure management system.

In general, the Finnish agricultural ammonia emission calculation system follows the principles of the Tier 2 method described in the EMEP/EEA Guidebook 2016. However, it has some features, which move it towards the Tier 3 method, such as the greater number of animal and manure categories than listed under Tier 2, and the inclusion of the emission abatement measures.

The manure management systems considered are (manure type acronym in brackets):

- slurry (S)
- deep litter (DL)
- solid manure system (SMS), divided into two separate systems:
    - farm yard manure system (FYM; urine absorbed in bedding material)
    - solid separation system (SS; urine and faeces managed separately, produces two kind of manure: dung with bedding (SSD), and urine (SSU)).

In contrast to the previous calculation systems, nitrogen flow approach is applied to total ammoniacal nitrogen (TAN) of manure in each stage of the manure management system instead of total nitrogen. This means that also the emissions of gaseous nitrogen compounds (except nitrous oxide emissions) are estimated based on the TAN content of manure. Because the effects of dietary changes or nitrogen transformation during the manure management chain affect the TAN content of manure and TAN is the basis of ammonia and other forms of gaseous N emissions, more precise emission estimates are now attained.

Due to the needs of nitrous oxide emission calculation, total nitrogen content of manure was also included in the nitrogen flow approach, as well as nitrogen from bedding materials. Moreover, the revised system considers also the transformation of manure nitrogen during manure storage: immobilisation of solid manure TAN to organic form and mineralisation of slurry organic nitrogen to TAN.

The main manure management phases considered in the calculation system are:

- animal housing,
- manure storing,
- manure spreading (included in the managed soils category in GHG emission inventory),
- outdoor yards.

Emissions from grazing are included in the model. In the GHG emission inventory, emissions from grazing are included in the category of managed soils.

The emission calculation model is part of the Finnish normative manure system (Luostarinen et al. 2017). The normative manure system is used to calculate normative manure quality and quantity data for various livestock animal categories, to be used e.g. in policymaking, research, technology development and manure fertilisation plans on farms. Major inputs from normative manure system to the agricultural emissions calculation system are nitrogen excretion rates for each animal category (divided between faeces and urine), and effects of the nitrogen transformation processes to quantity of TAN in a manure management system.

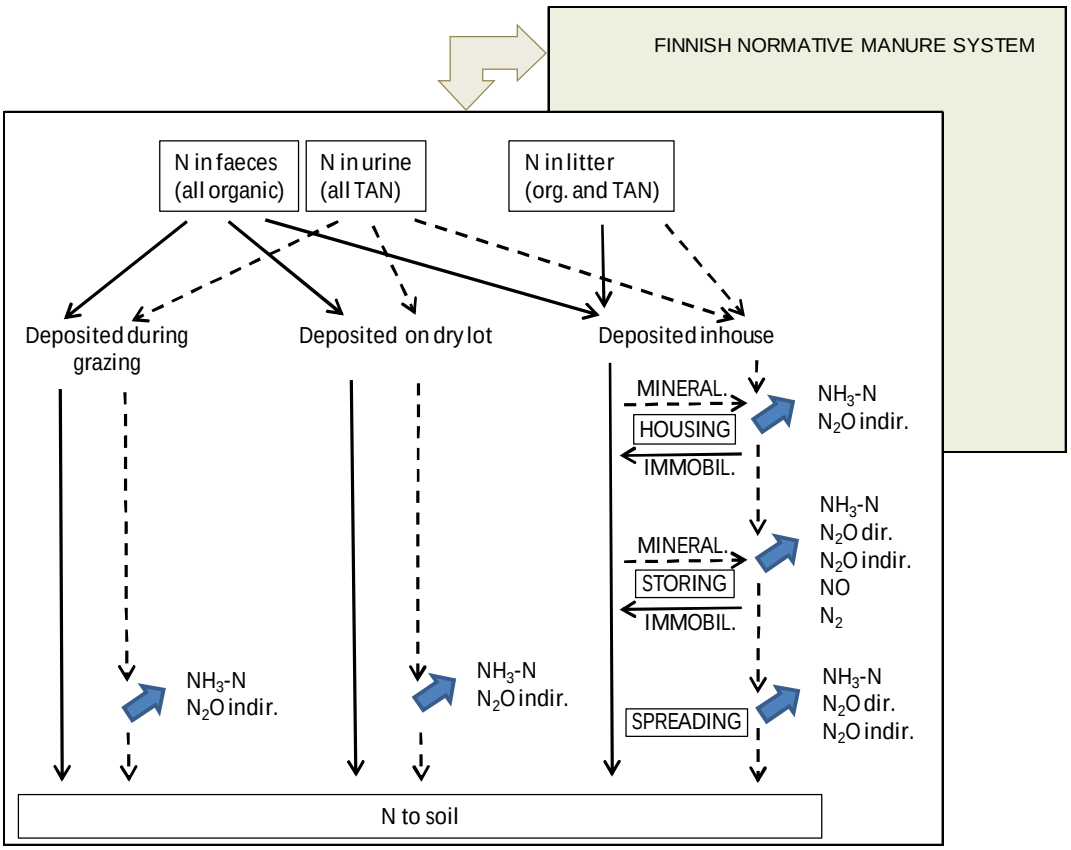


Fig. 5.6. Schematic diagram of the N flows in manure management *(incl. manure application and grazing) and the related gaseous nitrogen emission calculation system used for calculating the NH_3,N_2O, NO and N_2 emissions from manure management in Finland. Nitrogen transformation processes (immobilisation and mineralisation) are shown, as well as the link between emission calculation system and the Finnish normative manure system (see text for more information). Broad blue arrows: emissions of N-compounds to the atmosphere. Emissions are calculated separately for each animal category and manure management system. For clarity, all manure management systems are not shown in figure. TO BE EDITED*

Table 5.7.a. Animal categories considered in the emission calculation system; the detailed categorisation. The animal categories are the same as those in the Finnish normative manure system (Luostarinen et al. 2017).

CATTLE	PIGS	POULTRY	OTHER ANIMALS
Dairy cow, big breed	Farrowing sow + piglets (<10-12 kg)	Laying hen breeder	Horse
Dairy cow, small breed	Gestating sow	Cockerel (laying hen breeder, male)	
	Mating sow	Broiler	Pony (120-140)
Suckler cow, big breed	Boar (50- kg)	Broiler breeder hen	Pony, little (<120)
Suckler cow, small breed	Fattening pig (50- kg)	Broiler breeder, male	
		Chicken	Ewe
Heifer, beef breed (2- yrs)	Veaned pig (<30 kg)		Ram
Heifer, beef breed (1-2 yrs)	Veaned pig (<50 kg)	Groving turkey	Lamb
Heifer, dairy breed (2- yrs)		Turkey breeder hen	
Heifer, dairy breed (1-2 yrs)		Turkey breeder male	Female goat
Heifer, small breed (>2 yrs)		Other poultry	Male goat
Heifer, small breed (1-2 yrs)			Goatling
Bull, beef breed (>2 yrs)			Fox breeder, female
Bull, beef breed (1-2 yrs)			Fox breeder, male
Bull, dairy breed (>2 yrs)			Fox grover
Bull, dairy breed (1-2 yrs)			
Bull, small breed (1-2 yrs)			Mink breeder, female
Bull, small breed (>2 yrs)			Mink breeder, male
			Mink grover
Calf, female, beef (< 6 m)			Reindeer
Calf, female, beef (6-12 m)			
Calf, female, dairy (< 6 m)			
Calf, female, dairy (6-12 m)			

Calf, female, small breed (< 6 m)			
Calf, female, small breed (6-12 m)			
Calf, male, beef (< 6 m)			
Calf, male, beef (6-12 m)			
Calf, male, dairy (< 6 m)			
Calf, male, dairy (6-12 m)			
Calf, male, small breed (< 6 m)			
Calf, male, small breed (6-12 m)			

Table 5.7.b. Animal categories in the calculation system; the simpler categorisation. The animal categories are the same as those in the Finnish normative manure system (Luostarinen et al. 2017).

CATTLE	PIGS	POULTRY	OTHER ANIMALS
Dairy cow	Sow (with piglets)	Laying hen breeder (female)	Horse
Suckler cow	Boar (50- kg)	Cockerel (laying hen breeder, male)	Pony
Heifer >1 yr	Fattening pig (50- kg)	Broiler	Sheep
Bull >1 yr	Veaned pig (20-50 kg)	Broiler breeder hen	Goat
Calf <1 yr		Broiler breeder, male	Fox and racoon
		Chicken	Mink and fitch
		Turkey	Reindeer
		Other poultry	

A detailed description of the calculation of emissions is provided in Grönroos et al., 2017, chapter 2.1.1.2

Activity data

Animal numbers are received from TIKE (Information Centre of the Ministry of Agriculture and Forestry) (TIKE, 2016), the Finnish Trotting and Breeding Association of horses (Suomen Hippos, 2016) and from the statistics of Finnish Fur Sales (Finnish Fur Sales, 2016), as presented in Table 5.17.

The number of reindeer in the model is from the Yearbook of Farm Statistics (TIKE, 2016) and corresponds to the number of reindeer left alive during the reindeer herding year.

Emission factors

The domestic emission factors calculated on basis of national studies are presented in Table 5.8.

Table 5.8. Ammonia emissions factors for manure management (kg NH_3 / animal) (Grönroos et al., 2009/2015).

Year	Dairy cows	Suckler cows	Bulls	Heifers	Calves < 1 year	Sows with piglets	Boars	Fattening pigs (50-kg)	Weaned pigs (20-50 kg)
1980	14.69	9.60	11.11	7.17	5.47	9.43	7.14	6.53	2.80
1981	14.97	9.56	11.28	7.21	5.61	9.54	7.11	6.50	2.78
1982	15.25	9.52	11.45	7.25	5.75	9.64	7.09	6.47	2.76
1983	15.43	9.52	11.59	7.25	5.83	9.69	7.05	6.43	2.74
1984	15.83	9.44	11.80	7.33	6.04	9.86	7.03	6.41	2.71
1985	16.13	9.40	11.97	7.37	6.18	9.96	7.01	6.37	2.69
1986	16.41	9.39	12.07	7.40	6.34	10.12	7.00	6.36	2.67
1987	16.66	9.39	12.15	7.47	6.55	10.33	7.18	6.20	2.59
1988	16.93	9.39	12.19	7.51	6.62	10.44	7.22	6.21	2.58
1989	17.46	9.38	12.66	7.71	6.89	10.49	7.16	6.21	2.57
1990	19.16	9.38	13.17	7.97	7.15	10.51	7.26	6.22	2.56
1991	19.36	9.40	13.45	8.12	7.30	10.36	7.31	6.13	2.53
1992	19.63	9.42	13.50	8.17	7.42	10.44	7.22	6.08	2.51
1993	20.15	9.44	13.93	8.58	7.78	10.43	7.19	6.02	2.51
1994	20.84	9.46	14.28	8.76	8.00	10.33	7.14	6.00	2.51
1995	21.13	9.47	14.37	8.83	8.15	10.12	7.17	5.97	2.44
1996	21.44	9.67	14.55	8.91	8.22	10.11	7.14	5.93	2.41
1997	22.30	9.86	14.71	9.05	8.35	10.11	7.41	5.93	2.42
1998	22.88	10.06	14.89	9.13	8.46	10.16	7.45	5.98	2.43
1999	23.91	10.26	15.10	9.23	8.67	10.18	6.71	5.98	2.44
2000	25.12	10.46	15.58	9.52	8.98	10.22	6.66	5.98	2.45
2001	26.26	10.57	16.15	9.77	9.25	10.14	7.05	6.00	2.47

2002	27.36	10.67	17.03	10.04	9.56	10.40	7.18	6.03	2.49
2003	28.48	10.73	17.80	10.26	9.90	10.58	7.24	6.01	2.52
2004	29.76	11.02	18.35	10.55	10.22	10.75	7.35	6.01	2.53
2005	30.77	11.00	18.53	10.62	10.36	10.82	7.50	6.03	2.55
2006	31.06	10.80	18.80	10.92	10.30	10.88	7.61	6.00	2.54
2007	31.39	10.58	19.26	11.26	10.32	10.93	7.57	5.91	2.50
2008	31.58	10.50	19.23	11.54	10.21	10.98	7.42	5.84	2.47
2009	32.02	10.38	19.17	11.85	10.19	10.88	7.33	5.74	2.45
2010	32.47	10.48	19.53	12.27	10.26	10.91	7.35	5.67	2.40
2011	32.44	10.47	19.24	12.43	10.09	11.14	7.32	5.57	2.38
2012	32.34	10.21	18.71	12.44	9.78	10.71	7.09	5.45	2.33
2013	32.18	10.26	18.59	12.37	9.75	10.88	7.08	5.44	2.33
2014	31.93	10.66	19.27	12.31	9.96	10.97	7.14	5.38	2.32
2015	29.70	10.68	18.50	11.67	9.58	10.38	6.67	5.00	2.16

Table 5.8 continued…

Year	Sheep with lambs	Goats with gilts	Laying hens	Cockerels	Broilers	Broiler hens	Chicken	Turkeys	Other poultry
1980	0.93	1.18	0.20	0.39	0.08	0.00	0.09	0.19	0.20
1981	0.92	1.16	0.21	0.39	0.08	0.00	0.09	0.19	0.20
1982	0.90	1.14	0.22	0.39	0.08	0.00	0.10	0.19	0.20
1983	0.90	1.13	0.22	0.39	0.08	0.00	0.10	0.19	0.20
1984	0.87	1.10	0.24	0.39	0.08	0.00	0.11	0.19	0.20
1985	0.85	1.08	0.23	0.39	0.08	0.00	0.11	0.19	0.20
1986	0.84	1.06	0.24	0.39	0.08	0.00	0.12	0.19	0.20
1987	0.82	1.04	0.24	0.39	0.08	0.00	0.13	0.19	0.20
1988	0.81	1.02	0.24	0.39	0.08	0.00	0.13	0.19	0.20
1989	0.79	1.01	0.25	0.39	0.08	0.00	0.14	0.19	0.20
1990	0.78	0.99	0.26	0.39	0.08	0.18	0.14	0.19	0.20
1991	0.79	1.00	0.27	0.39	0.08	0.18	0.14	0.21	0.20
1992	0.81	1.01	0.27	0.39	0.07	0.18	0.14	0.22	0.20
1993	0.83	1.02	0.28	0.39	0.07	0.18	0.15	0.24	0.21
1994	0.84	1.03	0.28	0.39	0.07	0.18	0.15	0.22	0.21
1995	0.84	1.04	0.27	0.39	0.07	0.18	0.15	0.24	0.21
1996	0.86	1.04	0.28	0.39	0.07	0.18	0.15	0.23	0.21
1997	0.86	1.04	0.28	0.39	0.07	0.18	0.15	0.24	0.21
1998	0.87	1.04	0.29	0.39	0.08	0.18	0.15	0.24	0.22
1999	0.89	1.04	0.29	0.39	0.07	0.18	0.15	0.25	0.21
2000	0.91	1.04	0.29	0.39	0.07	0.18	0.16	0.26	0.22
2001	0.92	1.04	0.28	0.39	0.07	0.18	0.16	0.26	0.21
2002	0.93	1.04	0.27	0.39	0.07	0.18	0.16	0.27	0.21
2003	0.93	1.04	0.28	0.39	0.08	0.18	0.16	0.26	0.21
2004	0.94	1.04	0.29	0.39	0.08	0.18	0.16	0.27	0.22
2005	0.96	1.04	0.28	0.39	0.08	0.18	0.16	0.27	0.21
2006	1.04	1.12	0.27	0.37	0.07	0.18	0.15	0.26	0.20
2007	1.11	1.19	0.26	0.36	0.08	0.18	0.15	0.27	0.20
2008	1.19	1.27	0.25	0.34	0.08	0.18	0.14	0.27	0.20
2009	1.26	1.36	0.25	0.33	0.09	0.18	0.14	0.28	0.20
2010	1.34	1.44	0.24	0.31	0.08	0.18	0.13	0.29	0.20
2011	1.43	1.53	0.24	0.30	0.08	0.18	0.13	0.28	0.20
2012	1.51	1.62	0.25	0.28	0.08	0.18	0.12	0.29	0.20
2013	1.51	1.62	0.24	0.28	0.08	0.18	0.12	0.29	0.20
2014	1.51	1.62	0.23	0.28	0.08	0.18	0.12	0.28	0.20
2015	1.51	1.62	0.25	0.28	0.08	0.18	0.12	0.29	0.20

Year	Horses	Ponies	Minks&fitches	Foxes&racoons	Reindeer
1980	13.91	9.77	0.84	0.49	0.50
1981	14.14	9.95	0.84	0.49	0.50
1982	14.37	10.14	0.84	0.49	0.50
1983	14.29	10.12	0.84	0.49	0.50
1984	14.80	10.51	0.84	0.49	0.50
1985	15.02	10.70	0.84	0.49	0.50
1986	15.31	10.84	0.84	0.49	0.50
1987	15.42	11.19	0.84	0.49	0.50
1988	15.72	11.37	0.84	0.49	0.50
1989	16.02	11.61	0.84	0.49	0.50
1990	16.25	11.79	0.84	0.49	0.50
1991	15.86	11.48	0.85	0.49	0.50

1992	15.45	11.22	0.86	0.50	0.50
1993	15.15	10.97	0.87	0.50	0.50
1994	14.80	10.75	0.87	0.50	0.50
1995	14.40	10.50	0.88	0.50	0.50
1996	14.39	10.45	0.89	0.51	0.50
1997	14.34	10.49	0.90	0.51	0.50
1998	14.27	10.47	0.91	0.51	0.50
1999	14.28	10.46	0.92	0.51	0.50
2000	14.30	10.43	0.92	0.52	0.50
2001	15.01	10.91	0.96	0.52	0.50
2002	15.75	11.43	0.99	0.52	0.50
2003	16.48	11.92	1.02	0.52	0.50
2004	17.21	12.32	1.05	0.52	0.50
2005	17.87	12.70	1.09	0.52	0.50
2006	17.65	12.50	1.12	0.52	0.50
2007	17.49	12.33	1.15	0.52	0.50
2008	17.32	12.21	1.18	0.52	0.50
2009	17.28	12.17	1.18	0.52	0.50
2010	17.17	12.13	1.18	0.52	0.50
2011	17.18	12.10	1.18	0.52	0.50
2012	17.14	12.09	1.18	0.52	0.50
2013	17.22	12.12	1.18	0.52	0.50
2014	17.25	12.22	1.18	0.52	0.50
2015	17.30	12.30	1.18	0.52	0.50

Particle emissions

Note: the calculation of particle emissions is based on the previous version of the agriculture emissions calculation model including Guidebook 2016 emission factors and will be revised to the next submission.

Particle emissions are generated in manure management, harvesting and field preparation, storage and handling of agricultural crops and fertilizers and field burning of agricultural wastes and have been included in the inventory since the submission in 2004.

According to the Guidebook, particle emissions occur from both housed and free-range animals while the emission factors presented are for housed animals only. The most important parameters impacting particle emissions are feeding conditions, animal activity and bedding material.

In the 2015 submission the calculation of particulate matter emissions for manure management was revised to the Tier 2 method presented in Guidebook 2013, see Equation 1 below. Use of emission factors from Guidebook 2016 may be considered in the future, however, they were not considered in the current submission as the emission factors for TSP emissions were presented only on Tier 1 level in Guidebook 2016.

Equation 1. Particle emissions from animal husbandry

$$E_{PMi} = AAP_{animal} * x_{house} * \beta * \left(x_{slurry} * EF_{slurry} + \left(1 - x_{slurry}\right) * EF_{solid}\right)$$

where

E_{PM} = PM_{10} or $PM_{2.5}$ emissions for an animal category (in kg/a)

AAP = annual average population; number of animals of a particular category that are present, on average, within the year

β = mass units conversion factor (β=1kg/kg)

x_{house} = share of time the animals spend in the animal house (in a/a)

x_{slurry} = share of population kept in slurry based systems

EF_{slurry} = PM_{10} or $PM_{2.5}$ EF for slurry based system (in kg/AAP/a) EF_{solid} = PM_{10} or $PM_{2.5}$ EF for solid based system (in kg/AAP/a)

Emission factors applied for the equation are presented in Table 5.99 and livestock numbers for 1990-2015 in Table 5.17. Particle emissions are presented in Table 5.11. Data and the documentation of particle inventory will be checked to the next submission to be consistent with the latest version of the agriculture calculation model.

Data on grazing times (pasturing period in days), manure handling systems (deep litter, slurry or solid manure) and indoor/outdoor times (% of pastured animals, animals inside in nights during pasturing period, house inside in nights) presented in Table 6.6 were updated 2014 according to domestic studies (Grönroos et al., 2009/2014) for the years 2006-2012 . Detailed information on these are available in Grönroos al., 2009/2015 for years the 1990, 1995, 2000 and 2005. The values for the year 1990 are used over the period of 1990-1994 and the year 1995 values over the period of 1996-1999 etc.

Table 5.9. Default Tier 2 TSP. PM_{10} and $PM_{2.5}$ EFs for animal husbandry (EMEP/ EEA Guidebook 2013, Table 3.11)

Animal category	Housing type	Emission factors (kg/AAP/year)		
		TSP	PM_{10}	$PM_{2.5}$
Dairy cows	Solid	0.94	0.43	0.28
	Slurry	1.81	0.83	0.54
Suckler cows	Solid	0.52	0.24	0.16
	Slurry	0.69	0.32	0.21
Bulls >1 yr	Solid	0.52	0.24	0.16
	Slurry	0.69	0.32	0.21
Calves <1 yr	Solid	0.35	0.16	0.1
	Slurry	0.34	0.15	0.1
Heifers >1 yr	Solid	0.52	0.24	0.16
	Slurry	0.69	0.32	0.21
Horses	Solid	0.48	0.22	0.14
	Slurry	0	0	0
Ponies	Solid	0.48	0.22	0.14
	Slurry	0	0	0
Fattening pigs	Solid	0.83	0.37	0.07
	Slurry	0.7	0.31	0.06
Sows (with piglets)	Solid	1.77	0.8	0.14
	Slurry	1.36	0.61	0.11
Boars	Solid	0.83	0.37	0.07
	Slurry	0.7	0.31	0.06
Veaned pigs (20-50 kg)	Solid	0	0	0
	Slurry	0.36	0.18	0.029
Piglets	Solid	0	0	0
	Slurry	0.36	0.18	0.029
Laying hens	Cages	0.025	0.025	0.003
	Perchery	0.119	0.119	0.0229
Cockerels	Solid	0.032	0.032	0.004
	Slurry	0	0	0
Broiler hens	Solid	0.069	0.069	0.0091
	Slurry	0	0	0
Broilers	Solid	0.069	0.069	0.0091
	Slurry	0	0	0
Other poultry	Solid	0.032	0.032	0.004
	Slurry	0	0	0
Turkeys	Solid	0.032	0.032	0.004
	Slurry	0	0	0

Table 5.10. Parameters by animal category 1990, 1995, 2000, 2005 - grazing times, manure handling and outdoor/ indoors times

	Grazing times, pasturing period (days)			
	1990	1995	2000	2005
Dairy cows	125	125	125	125
Suckler cows	140	140	140	140
Bulls	0	0	0	0
Calves < 1 yr	100	100	100	100
Heifers >1 yr	140	140	140	140
Horses	140	140	140	140
Ponies	140	140	140	140
Sheep with lambs	140	130	130	130
Goat with gilts	140	130	130	130
Fattening pigs	0	0	0	0
Sows (with piglets)	90	0	0	0
Boars	90	0	0	0
Veaned pigs (20-50kg)	0	0	0	0
Reindeer	365	365	365	365

	Percentage of pastured animals (%)			
	1990	1995	2000	2005
Dairy cows	90	90	90	90
Suckler cows	90	95	95	95
Bulls	0	0	0	0
Calves < 1 yr	30	25	25	25
Heifers >1 yr	95	90	90	90
Horses	95	95	95	95
Ponies	95	95	95	95
Sheep with lambs	95	90	90	90
Goat with gilts	95	90	90	90
Reindeer	100	100	100	100
	Animals inside in nights during pasturing period (%)			
	1990	1995	2000	2005
Dairy cows	60	75	90	100
	Hours inside in nights (hours)			
	1990	1995	2000	2005
Dairy cows	12	12	12	12
	Percentage of manure that is handled as deep litter (%)			
	1990	1995	2000	2005
Dairy cows	2	1	1	1
Suckler cows	40	39	39	39
Bulls	6	6	6	6
Calves < 1 yr	10	3	3	3
Heifers >1 yr	3	3	3	3
Horses	0	40	40	0
Ponies	0	40	40	0
Sheep with lambs	90	90	90	90
Goat with gilts	90	90	90	90
Fattening pigs	5	5	5	5
Sows (with piglets)	5	5	5	5
Boars	5	5	5	5
Veaned pigs (20-50kg)	5	5	5	5
Laying hens	5	5	5	5
Cockerels	5	5	5	5
Broiler hens	100	99	99	100
Broilers	100	99	99	100
Chickens	5	5	5	5
Other poultry	40	40	40	40
Turkeys	100	99	99	100
Reindeer	0	0	0	0
Fox and racoon	0	0	0	0
Mink and fitch	0	0	0	0
	Percentage of manure that is handled as slurry (%)			
	1990	1995	2000	2005
Dairy cows	30	35	45	63
Suckler cows	5	5	25	30
Bulls	30	40	40	40
Calves < 1 yr	30	38	38	38
Heifers >1 yr	30	36	36	36
Fattening pigs	50	75	75	80
Sows (with piglets)	20	25	25	30
Boars	20	25	25	30
Veaned pigs (20-50kg)	50	75	75	80
Laying hens	0	2	2	2
Cockerels	0	1	1	0
Broiler hens	0	1	1	0
Broilers	0	1	1	0
Chickens	0	2	2	0
Other poultry	0	0	0	0
Turkeys	0	1	1	0
	Percentage of manure that is handled as solid manure (%)			
	1990	1995	2000	2005
Dairy cows	68	64	54	36
Suckler cows	55	56	36	31
Bulls	64	54	54	54
Calves < 1 yr	60	59	59	59
Heifers >1 yr	67	61	61	61
Horses	100	60	60	100
Ponies	100	60	60	100
Sheep with lambs	10	10	10	10

Goat with gilts	10	10	10	10
Fattening pigs	45	20	20	15
Sows (with piglets)	75	70	70	65
Boars	75	70	70	65
Veaned pigs (20-50kg)	45	20	20	15
Laying hens	95	93	93	93
Cockerels	95	94	94	95
Chicken	95	93	93	95
Other poultry	60	60	60	60
Reindeer	100	100	100	100
Fox and racoon	100	100	100	100
Mink and fitch	100	100	100	100

Table 5.11 Particle emissions (kt) by animal categories 1990-2015

(kt)	Dairy cows			Suckler cows			Bulls			Heifers			Horses			Ponies		
Year	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
1990	0.420	0.195	0.125	0.009	0.004	0.003	0.085	0.039	0.026	0.079	0.037	0.024	0.010	0.005	0.003	0.001	0.001	0.000
1991	0.382	0.177	0.114	0.013	0.006	0.004	0.082	0.038	0.025	0.077	0.036	0.024	0.010	0.005	0.003	0.002	0.001	0.000
1992	0.367	0.170	0.109	0.018	0.008	0.005	0.082	0.038	0.025	0.077	0.035	0.023	0.011	0.005	0.003	0.002	0.001	0.000
1993	0.366	0.169	0.109	0.021	0.010	0.006	0.079	0.037	0.024	0.079	0.036	0.024	0.011	0.005	0.003	0.002	0.001	0.000
1994	0.357	0.166	0.106	0.021	0.010	0.006	0.082	0.038	0.025	0.078	0.036	0.024	0.010	0.005	0.003	0.002	0.001	0.000
1995	0.342	0.158	0.102	0.019	0.009	0.005	0.064	0.030	0.020	0.072	0.033	0.022	0.011	0.005	0.003	0.002	0.001	0.000
1996	0.336	0.156	0.100	0.020	0.009	0.006	0.067	0.031	0.021	0.077	0.035	0.023	0.011	0.005	0.003	0.002	0.001	0.000
1997	0.335	0.155	0.100	0.021	0.010	0.006	0.071	0.033	0.022	0.075	0.035	0.023	0.012	0.005	0.004	0.002	0.001	0.001
1998	0.329	0.152	0.098	0.019	0.009	0.006	0.067	0.031	0.021	0.072	0.034	0.022	0.012	0.006	0.004	0.002	0.001	0.001
1999	0.319	0.148	0.095	0.019	0.009	0.006	0.069	0.032	0.021	0.071	0.033	0.022	0.012	0.006	0.004	0.002	0.001	0.001
2000	0.312	0.145	0.093	0.018	0.008	0.005	0.068	0.031	0.021	0.070	0.033	0.022	0.013	0.006	0.004	0.002	0.001	0.001
2001	0.304	0.141	0.090	0.017	0.008	0.005	0.065	0.030	0.020	0.069	0.032	0.021	0.013	0.006	0.004	0.002	0.001	0.001
2002	0.298	0.138	0.089	0.018	0.008	0.005	0.068	0.031	0.021	0.068	0.032	0.021	0.013	0.006	0.004	0.002	0.001	0.001
2003	0.286	0.133	0.085	0.018	0.008	0.005	0.068	0.031	0.021	0.068	0.031	0.021	0.013	0.006	0.004	0.002	0.001	0.001
2004	0.278	0.129	0.083	0.020	0.009	0.006	0.065	0.030	0.020	0.066	0.030	0.020	0.013	0.006	0.004	0.002	0.001	0.001
2005	0.273	0.127	0.081	0.022	0.010	0.007	0.063	0.029	0.019	0.064	0.030	0.020	0.014	0.006	0.004	0.002	0.001	0.001
2006	0.265	0.123	0.079	0.025	0.011	0.007	0.066	0.031	0.020	0.065	0.030	0.020	0.014	0.007	0.004	0.002	0.001	0.001
2007	0.254	0.118	0.075	0.027	0.013	0.008	0.065	0.030	0.020	0.063	0.029	0.019	0.015	0.007	0.005	0.002	0.001	0.001
2008	0.248	0.115	0.074	0.031	0.014	0.009	0.064	0.030	0.020	0.063	0.029	0.019	0.015	0.007	0.005	0.002	0.001	0.001
2009	0.249	0.115	0.074	0.033	0.015	0.010	0.064	0.030	0.020	0.062	0.029	0.019	0.016	0.007	0.005	0.002	0.001	0.001
2010	0.248	0.115	0.074	0.035	0.016	0.010	0.067	0.031	0.021	0.062	0.029	0.019	0.016	0.007	0.005	0.002	0.001	0.001
2011	0.245	0.113	0.073	0.036	0.017	0.011	0.065	0.030	0.020	0.062	0.029	0.019	0.016	0.007	0.005	0.003	0.001	0.001
2012	0.243	0.113	0.072	0.037	0.017	0.011	0.064	0.030	0.020	0.061	0.028	0.019	0.016	0.007	0.005	0.003	0.001	0.001
2013	0.243	0.112	0.072	0.036	0.017	0.011	0.064	0.030	0.020	0.062	0.028	0.019	0.016	0.007	0.005	0.003	0.001	0.001
2014	0.245	0.113	0.073	0.037	0.017	0.011	0.065	0.030	0.020	0.060	0.028	0.018	0.016	0.007	0.005	0.003	0.001	0.001
2015	0.245	0.113	0.073	0.037	0.017	0.011	0.064	0.030	0.020	0.059	0.027	0.018	0.016	0.007	0.005	0.003	0.001	0.001

kt	Fattening pigs			Sows			Boars			Veaned pigs		
Year	TSP	PM10	PM2.5	TSP	PM10	PM2.5	TSP	PM10	PM2.5	TSP	PM10	PM2.5
1990	0.390	0.191	0.031	0.196	0.097	0.016	0.006	0.003	0.000	0.056	0.028	0.005
1991	0.380	0.186	0.030	0.191	0.094	0.015	0.006	0.003	0.000	0.055	0.027	0.004
1992	0.367	0.179	0.029	0.185	0.091	0.015	0.005	0.003	0.000	0.053	0.026	0.004
1993	0.360	0.176	0.029	0.181	0.089	0.014	0.005	0.003	0.000	0.052	0.026	0.004
1994	0.367	0.179	0.029	0.185	0.091	0.015	0.005	0.003	0.000	0.053	0.026	0.004
1995	0.402	0.197	0.032	0.177	0.087	0.014	0.006	0.003	0.001	0.083	0.041	0.007
1996	0.397	0.194	0.032	0.198	0.097	0.016	0.006	0.003	0.001	0.083	0.042	0.007
1997	0.420	0.205	0.034	0.204	0.100	0.016	0.007	0.003	0.001	0.099	0.050	0.008
1998	0.375	0.183	0.030	0.205	0.101	0.016	0.008	0.004	0.001	0.096	0.048	0.008
1999	0.385	0.188	0.031	0.198	0.097	0.016	0.006	0.003	0.000	0.080	0.040	0.006
2000	0.361	0.177	0.029	0.203	0.100	0.016	0.006	0.003	0.000	0.078	0.039	0.006
2001	0.349	0.171	0.028	0.180	0.089	0.014	0.005	0.003	0.000	0.079	0.039	0.006
2002	0.361	0.176	0.029	0.189	0.093	0.015	0.005	0.003	0.000	0.080	0.040	0.006
2003	0.396	0.194	0.032	0.196	0.096	0.016	0.005	0.002	0.000	0.080	0.040	0.006
2004	0.394	0.192	0.032	0.192	0.095	0.015	0.005	0.002	0.000	0.079	0.039	0.006
2005	0.410	0.200	0.033	0.194	0.096	0.015	0.004	0.002	0.000	0.089	0.045	0.007
2006	0.408	0.199	0.033	0.188	0.092	0.015	0.004	0.002	0.000	0.094	0.047	0.008
2007	0.443	0.217	0.035	0.192	0.094	0.015	0.004	0.002	0.000	0.099	0.050	0.008
2008	0.450	0.220	0.036	0.185	0.091	0.015	0.004	0.002	0.000	0.102	0.051	0.008
2009	0.439	0.214	0.035	0.168	0.083	0.013	0.003	0.002	0.000	0.097	0.049	0.008
2010	0.435	0.213	0.035	0.165	0.081	0.013	0.003	0.001	0.000	0.091	0.046	0.007
2011	0.420	0.205	0.034	0.157	0.077	0.013	0.003	0.002	0.000	0.094	0.047	0.008
2012	0.426	0.208	0.034	0.146	0.072	0.012	0.003	0.001	0.000	0.087	0.044	0.007
2013	0.437	0.214	0.035	0.138	0.068	0.011	0.002	0.001	0.000	0.094	0.047	0.008
2014	0.414	0.202	0.033	0.133	0.065	0.011	0.002	0.001	0.000	0.085	0.043	0.007
2015	0.409	0.200	0.033	0.130	0.064	0.010	0.002	0.001	0.000	0.087	0.044	0.007

kt	Laying hens			Cockerels			Broiler hens			Broilers			Other poultry			Turkeys		
Year	TSP	PM10	PM2.5	TSP	PM10	PM2.5	TSP	PM10	PM2.5	TSP	PM10	PM2.5	TSP	PM10	PM2.5	TSP	PM10	PM2.5
1990	0.131	0.131	0.020	0.001	0.001	0.000	0.022	0.022	0.003	0.156	0.156	0.020	0.002	0.002	0.000	0.002	0.002	0.000
1991	0.112	0.112	0.017	0.001	0.001	0.000	0.034	0.034	0.004	0.169	0.169	0.022	0.003	0.003	0.001	0.002	0.002	0.000
1992	0.107	0.107	0.017	0.001	0.001	0.000	0.046	0.046	0.006	0.182	0.182	0.024	0.004	0.004	0.001	0.002	0.002	0.000
1993	0.109	0.109	0.017	0.001	0.001	0.000	0.059	0.059	0.008	0.196	0.196	0.026	0.005	0.005	0.001	0.002	0.002	0.000
1994	0.111	0.111	0.017	0.001	0.001	0.000	0.071	0.071	0.009	0.209	0.209	0.027	0.005	0.005	0.001	0.002	0.002	0.000
1995	0.113	0.113	0.018	0.001	0.001	0.000	0.084	0.084	0.011	0.222	0.222	0.029	0.006	0.006	0.001	0.003	0.003	0.000
1996	0.113	0.113	0.018	0.001	0.001	0.000	0.098	0.098	0.013	0.211	0.211	0.028	0.005	0.005	0.001	0.003	0.003	0.000
1997	0.112	0.112	0.017	0.001	0.001	0.000	0.105	0.105	0.013	0.255	0.255	0.033	0.003	0.003	0.001	0.004	0.004	0.000
1998	0.103	0.103	0.016	0.001	0.001	0.000	0.121	0.121	0.016	0.286	0.286	0.037	0.003	0.003	0.001	0.005	0.005	0.001
1999	0.091	0.091	0.014	0.000	0.000	0.000	0.134	0.134	0.017	0.312	0.312	0.041	0.003	0.003	0.001	0.007	0.007	0.001
2000	0.084	0.084	0.013	0.000	0.000	0.000	0.127	0.127	0.016	0.412	0.412	0.054	0.003	0.003	0.001	0.007	0.007	0.001
2001	0.087	0.087	0.013	0.000	0.000	0.000	0.138	0.138	0.018	0.281	0.281	0.037	0.003	0.003	0.001	0.015	0.015	0.002
2002	0.087	0.087	0.014	0.000	0.000	0.000	0.141	0.141	0.018	0.300	0.300	0.039	0.003	0.003	0.001	0.017	0.017	0.002
2003	0.082	0.082	0.013	0.000	0.000	0.000	0.121	0.121	0.016	0.315	0.315	0.041	0.003	0.003	0.001	0.019	0.019	0.002
2004	0.083	0.083	0.013	0.000	0.000	0.000	0.101	0.101	0.013	0.290	0.290	0.038	0.002	0.002	0.000	0.017	0.017	0.002
2005	0.085	0.085	0.013	0.000	0.000	0.000	0.160	0.160	0.021	0.285	0.285	0.037	0.002	0.002	0.000	0.016	0.016	0.002
2006	0.084	0.084	0.013	0.000	0.000	0.000	0.142	0.142	0.018	0.279	0.279	0.036	0.001	0.001	0.000	0.016	0.016	0.002
2007	0.085	0.085	0.013	0.000	0.000	0.000	0.123	0.123	0.016	0.264	0.264	0.035	0.002	0.002	0.000	0.014	0.014	0.002
2008	0.086	0.086	0.013	0.001	0.001	0.000	0.119	0.119	0.015	0.295	0.295	0.039	0.002	0.002	0.000	0.013	0.013	0.002
2009	0.079	0.079	0.012	0.000	0.000	0.000	0.115	0.115	0.015	0.256	0.256	0.033	0.001	0.001	0.000	0.010	0.010	0.001
2010	0.092	0.092	0.014	0.000	0.000	0.000	0.151	0.151	0.019	0.240	0.240	0.031	0.001	0.001	0.000	0.009	0.009	0.001
2011	0.089	0.089	0.014	0.001	0.001	0.000	0.147	0.147	0.019	0.282	0.282	0.037	0.001	0.001	0.000	0.010	0.010	0.001
2012	0.086	0.086	0.013	0.001	0.001	0.000	0.165	0.165	0.021	0.314	0.314	0.041	0.001	0.001	0.000	0.009	0.009	0.001
2013	0.093	0.093	0.014	0.001	0.001	0.000	0.182	0.182	0.023	0.357	0.357	0.047	0.001	0.001	0.000	0.009	0.009	0.001
2014	0.099	0.099	0.015	0.001	0.001	0.000	0.191	0.191	0.024	0.382	0.382	0.050	0.001	0.001	0.000	0.009	0.009	0.001
2015	0.095	0.095	0.015	0.001	0.001	0.000	0.192	0.192	0.025	0.356	0.356	0.047	0.002	0.002	0.000	0.008	0.008	0.001

NMVOC emissions

Emissions of NMVOC in manure management originate from silage store and feed, manure in the barns, outdoor manure stores, field application of manure and grazing of animals. In-house emissions are reported in the categories under NFR 3B and emissions of field application of manure and grazing under 3Da2a and 3Da3 respectively.

The calculation method for NMVOC emissions is presented in details in Munther et al., 2017.

The main parameters for calculation are gross energy intake (GEI as MJs), volatile solids excreted (VS), annual average population (AAP) which are provided by Natural Resources Institute Finland (LUKE). Detail increasing parameters such as the share of time the animals spend in housing, fractions of silage store and feed (Table 5.15) are national values. Data is available for GEI and VS for the years 1990-2015 and for AAP for the years 1980-2015. The livestock classification varies between the data sources. Gross energy intake (Table 5.13) is available for dairy cows, non-dairy cattle, suckler cows, bulls (age over 1 year), heifers, calves (under 1 year) and non-dairy gross energy. Data of gross energy intakes as required by the EF of cattle are presented in Table 5.13. For VS (Table 5.14), primary data is available for dairy cows, non-dairy cattle, suckler cows, bulls (age over 1 year), heifers, calves (under 1 year), swine, sow, piglets, fattening pigs, boars, weaned pigs, sheep, goats, horses, poultry, laying hens, chickens, cockerels, broiler hens, broilers, turkeys, other poultry (ducks), other animals, reindeer, fur animals, mink and fitch, fox and raccoon.

Parameters based on EMEP/EAA Guidebook 2016 are presented in Table 5.12.

Table 5.12 Parameters for NMVOC emissions from manure management.

NFR	Livestock	$EF_{silage_feeding}$	EF_{house}	$EF_{grazing}$	Unit
3B1a	Dairy cattle	2,00E-04	3,53E-05	6,90E-06	kg NMVOC kg/MJ feed intake
3B1b	Non-dairy	2,00E-04	3,53E-05	6,90E-06	kg NMVOC kg/MJ feed intake
3B2	Sheep	1,08E-02	1,61E-03	2,35E-05	kg NMVOC/kg VS excreted
3B3	Swine	1,70E-03			kg NMVOC/kg VS excreted
3B3	Swine (sows)		7,04E-03		kg NMVOC/kg VS excreted
3B4a	Buffalo	1,08E-02	1,61E-03	2,35E-05	kg NMVOC/kg VS excreted
3B4d	Goats	1,08E-02	1,61E-03	2,35E-05	kg NMVOC/kg VS excreted
3B4e	Horses	1,08E-02	1,61E-03	2,35E-05	kg NMVOC/kg VS excreted
3B4f	Mules and	1,08E-02	1,61E-03	2,35E-05	kg NMVOC/kg VS excreted
3B4gi	Laying hens	5,68E-03			kg NMVOC/kg VS excreted

3B4gii		9,15E-03			kg NMVOC/kg VS excreted
3B4giii	Turkeys		5,68E-03		kg NMVOC/kg VS excreted
3B4giv	Other poultry	5,68E-03			kg NMVOC/kg VS excreted
3B4h	Other animals	5,68E-03			kg NMVOC/kg VS excreted
3B4h	Other animals	1,61E-03			kg NMVOC/kg VS excreted
3B4h	Other animals	1,61E-03	2,35E-05		kg NMVOC/kg VS excreted

To accommodate the emission factors to the categorization of livestock in the Finnish Normative Manure system, the following applications are made:

- Heifers: emission factor of dairy cattle applied
- Bulls: emission factor of dairy cattle applied
- Calves: emission factor of dairy cattle applied
- Weaned pig (20-50kg): emission factor of swine (fattening pigs)

Table 5.13. Gross energy intake (MJ/day) in five year intervals

Livestock	1980	1985	1990	1995	2000	2005	2010	2015
Dairy cows	249.45	257.54	263.54	276.95	300.47	322.66	340.55	353.14
Suckler cows	209.16	211.47	212.70	219.09	224.40	229.82	240.67	241.24
Bulls (age over 1 year)	125.89	129.21	131.87	136.31	140.79	156.30	165.50	165.86
Heifers	100.48	102.67	104.18	107.89	113.48	120.99	127.37	127.23
Calves (under 1 year)	67.21	68.98	70.34	72.96	76.81	82.65	88.21	89.03
Non-dairy GE	86.38	89.51	91.71	96.70	103.15	113.12	125.42	125.95

Table 5.14. Volatile solids (VS) excreted in five year intervals (kg/head/day)

Livestock	1980	1985	1990	1995	2000	2005	2010	2015
Dairy cows	4.23	4.37	4.47	4.70	5.09	5.47	5.77	5.99
Non-dairy cattle	1.45	1.51	1.55	1.65	1.76	1.94	2.17	2.19
Suckler cows	4.17	4.22	4.24	4.37	4.48	4.58	4.80	4.81
Bulls (age over 1 year)	2.13	2.19	2.24	2.31	2.39	2.65	2.81	2.81
Heifers	1.75	1.79	1.82	1.88	1.98	2.11	2.22	2.22
Calves (under 1 year)	1.09	1.12	1.14	1.18	1.24	1.34	1.43	1.44
Swine	0.22	0.22	0.22	0.21	0.22	0.22	0.22	0.21
sow	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
piglets	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
fattening pigs	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
boars	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
veaned pigs	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Sheep	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Goats	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Horses	2.13	2.13	2.13	2.13	2.13	2.13	2.13	2.13
Poultry	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
laying hens	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
chicken	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
cockerels	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
broiler hens	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
broilers	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
turkeys	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
other poultry (ducks)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Other animals								
Reindeer	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
Fur animals	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Mink and fitch	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Fox and racoon	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14

Emissions are calculated separately for silage store and feeding, housing, manure storage and field application of manure. The emissions are calculated for every animal category with annually calculated parameters (where available). In each activity, emissions are calculated for the count of one animal. The animal and year specific emissions are then multiplied by the average annual population. The corresponding equation is presented.

$$E_{NMVOC\ i,j} = AAP_{i,j} * \left(E_{silage_{store}} + E_{silage_{feed}} + E_{house} + E_{manure_{storage}} + E_{manure_{application}} + E_{grazing}\right)_{i,j}$$

Where,
i = Livestock category
j = Active year
$AAP_{i,j}$ = Annual average population within the calculated livestock category in the given year
$E_{silage_{store}}$ = Emissions from silage store
$E_{silage_{feed}}$ = Emissions from silage feeding
E_{house} = Emissions from housing
$E_{manure_{storage}}$ = Emissions from manure in barns and outside stores
$E_{manure_{application}}$ = Emissions from field application of manure (reported under 3Da2a)
$E_{grazing}$ = Emissions from grazing (reported under 3Da3)

Emissions from housing are estimated based on the time that the livestock spends in buildings, which is estimated annually. The estimates are retrieved from the Finnish Normative Manure System. The emission values are calculated with equations 2 and 3 which are similar to each other with the exception of primary activity data (gross feed intake as (MJ/a) and volatile solids excreted (kg/a)) being different for cattle and other livestock.

Cattle:

$$E_{house} = MJ_i * X_{house_i} * EF_{house_i}$$

Other livestock:

$$E_{house} = VS_i * X_{house_i} * EF_{house_i}$$

Where,
i = Livestock category
MJ_i = Gross feed intake as (MJ/a)
VS_i = Volatile solids excreted (kg/a)
X_{house_i} = Annual proportion of time the livestock spends inside buildings (%)
EF_{house_i} = Emission factor for emissions from housing

Table 5.15. Annual proportion of time the livestock spends inside buildings in five year intervals

Livestock	1980	1985	1990	1995	2000	2005	2010	2015
Dairy cow	0.74	0.74	0.78	0.81	0.83	0.85	0.87	0.88
Suckler cow	0.65	0.65	0.65	0.64	0.64	0.64	0.60	0.59
Heifer >1 yr	0.65	0.65	0.64	0.65	0.65	0.65	0.73	0.76
Bull >1 yr	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Calf <1 yr	0.86	0.89	0.92	0.93	0.93	0.93	0.91	0.90
Sow (with piglets)	0.90	0.95	0.99	1.00	1.00	1.00	1.00	1.00
Boar (50- kg)	1.00	1.00	0.99	1.00	1.00	1.00	1.00	1.00
Fattening pig (50- kg)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Veaned pig (20-50 kg)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Laying hen breeder (female)	0.92	0.98	1.00	1.00	1.00	1.00	1.00	1.00
Cockerel (laying hen breeder. male)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Broiler	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Broiler breeder hen	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Broiler breeder. male	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Chicken	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Turkey	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Other poultry	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Horse	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
Pony	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
Sheep	0.68	0.66	0.64	0.68	0.68	0.68	0.66	0.65
Goat	0.68	0.66	0.64	0.68	0.68	0.68	0.66	0.65
Fox and racoon	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Mink and fitch	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Reindeer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Emissions from silage store are estimated based on the time that the livestock spends in buildings and by estimating the fraction of silage feeding in the given livestock category. In order to apply the formula it is to be assumed that silage feed always occurs inside livestock buildings.

Cattle:

$$E_{silage_{store}} = MJ_i * X_{house_i} * \left(EF_{silage_{feed}} * Frac_{silage}\right)_i$$

Other livestock:

$$E_{silage_{store}} = VS_i * X_{house_i} * \left(EF_{silage_{feed}} * Frac_{silage}\right)_i$$

Where,

i = Livestock category

$EF_{silage_{feed}}$ = Emission factor for silage feed

$Frac_{silage}$ = Proportion of silage as feed (%)

Table 5.16. Fraction of feed as silage for all livestock categories

Livestock	Fracsilage	Livestock	Fracsilage
Dairy cow	0,56	Chicken	0
Suckler cow	1	Turkey	0
Heifer >1 yr	0,7	Other poultry	0
Bull >1 yr	0,61	Horse	0,375
Calf <1 yr	0	Pony	0,375
Sow (with piglets)	0	Sheep	0,68
Boar (50- kg)	0	Goat	0,67
Fattening pig (50- kg)	0	Fox and racoon	0
Veaned pig (20-50 kg)	0	Mink and fitch	0
Laying hen breeder (female)	0	Reindeer	0
Cockerel (laying hen breeder, male)	0		
Broiler	0		
Broiler breeder hen	0		
Broiler breeder, male	0		

Emissions from silage store are estimated as the share of stored silage in relation to silage in the feeding table by introducing an estimate of the fraction of the stored silage to equations *4* and *5*.

Cattle:

$$E_{silage_{store}} = MJ_i * X_{house_i} * \left(EF_{silage_{feed}} * Frac_{silage} * Frac_{silage_{store}}\right)_i$$

$$E_{silage_{store}} = VS_i * X_{house_i} * \left(EF_{silage_{feed}} * Frac_{silage} * Frac_{silage_{store}}\right)_i$$

Where,

i = Livestock category

$Frac_{silage_{store}}$ = The relative share of stored silage in relation to silage in feeding table (%)

The guidebook default for $Frac_{silage_{store}}$ of 0.25 is used for all species and all years. Emission factors of silage feeding, however, are not cross-applied between the species except for categories with close resemblance to each other. The model suggests emissions from silage store to occur on all cattle, horses, sheep and goats.

Manure storage

The proportion of emissions from storage is assumed to possess the same ratio as with ammonia. The equation only factorizes NMVOC emissions from housing with the storage/building-ratio of ammonia emissions. Ammonia emissions are calculated in the Finnish Normative Manure System.

$$\boldsymbol{E_{manure_{storage}}} = \boldsymbol{E_{NMVOC_{house}}} * \left(\frac{E_{NH3_{storage}}}{E_{NH3_{building}}}\right)_{i}$$

Where,

i = Livestock category

$E_{NMVOC_{house}}$ = NMVOC emissions from housing

$E_{NH3_{storage}}$ = Ammonia emissions from storage

$E_{NH3_{building}}$ = Ammonia emissions from housing

Data on manure management systems

The distribution of manure management systems has been estimated by using different data sources. Information on manure management is collected by LUKE but not at the detailed level needed for emissions inventory purposes. Use of manure management systems is estimated based on data from the Information Centre of the Ministry of Agriculture and Forestry, the results of a questionnaire sent to Regional Employment and Economic Development Centres and to Regional Environment Centres, and through expert estimates (Sipilä, I. and Kapuinen, P. MTT) as described in Grönroos et al., (2009). Due to the low response rate on the questionnaire (only 8 questionnaires were received back), the distribution of different manure management systems is quite uncertain. A new questionnaire (Grönroos J & Luostarinen S, Suomen lantojen käsittely (*Manure management in Finland*, Manuscript.) has been made in 2013 to 11 120 farms, stables or fur farms, with a response rate of about 23 % answered. Based on this study, activity data of shares of manure management systems for years 1990-2005 stayed the same but from 2006 onwards the values were updated. In addition, dairy pasture parameters were updated from 2006 onwards series by updating the year 2012 management system data and interpolating the years 2006-2011. The values for 2013 and 2015 are based on the estimated trend between 2012 and 2020 where a continued increase for the share of slurry is assumed. Information about changes made to the data are presented in Grönroos 2014 (in Finnish, https://helda.helsinki.fi/handle/10138/152766).

The share of manure in dry lots (1-3% of extracted manure) is a rough estimate which will be updated when more data is available (Finland's EU GHG-NIR 2013, 2015),

Table 5.17. Animal numbers in Finland (x 1 000 heads).

Year	Cattle[1]	Dairy	Suckler	Bulls	Heifers	Calves	Horses	Ponies	Sheep
1990	1 360	490	14	149	219	488	39.4	6.0	103
1991	1 310	446	21	144	214	486	41.7	6.4	107
1992	1 273	428	28	143	211	463	42.7	6.4	108
1993	1 252	426	33	139	217	437	42.7	6.3	120
1994	1 233	417	33	144	215	425	42.1	6.2	121
1995	1 148	399	29	109	189	422	43.7	6.2	159
1996	1 146	392	31	115	201	407	45.6	6.4	150
1997	1 142	391	32	121	197	402	47.9	6.8	150
1998	1 117	383	31	115	190	398	49.2	6.9	128
1999	1 087	372	30	118	188	379	49.6	6.6	107
2000	1 057	364	28	115	185	365	50.7	6.7	100
2001	1 037	355	27	111	182	362	51.9	6.7	96
2002	1 025	348	28	115	180	354	52.1	7.0	96
2003	1 000	334	28	116	179	344	52.9	7.3	98
2004	969	324	31	111	173	330	53.8	7.3	109
2005	959	319	35	108	169	329	56.1	7.7	90
2006	949	309	39	113	171	318	58.1	8.0	117
2007	927	296	43	110	167	311	59.5	8.5	119
2008	915	289	48	109	165	305	60.6	8.8	122.2
2009	918	290	52	110	163	304	63.0	9.3	117.7
2010	926	289	55	114	164	303	64.6	9.7	125.7
2011	914	286	57	111	162	299	65.3	10.2	129.1
2012	913	284	58	109	160	303	64.0	10.2	130

2013	912	283	57	110	162	300	65	10.4	136
2014	914	285	58	110	158	303	64	10.4	138
2015	915	285	59	109	155	307	64	10.4	155

Year	Goats with gilts	Swine[3]	Sows with piglets	Fattening pigs (50- kg)	Boars	Veaned pigs (20-50 kg)	Reindeer	Mink and polecat	Fox and racoon
1990	5.9	936	179	438	5.9	313	239	1805	1478
1991	5.4	911	174	426	5.8	305	260	1505	1092
1992	4.8	879	168	411	5.6	294	232	1576	1272
1993	4.8	862	165	403	5.5	289	215	1659	1221
1994	5.7	879	168	411	5.6	294	214	1639	1645
1995	6.0	925	161	451	6.5	306	208	1945	1804
1996	6.5	940	180	445	6.6	309	213	1801	2344
1997	8.0	1 029	185	470	7.1	367	203	1828	2493
1998	8.1	972	187	421	7.8	357	196	1646	2322
1999	7.9	914	180	431	5.8	297	195	1733	1972
2000	8.6	884	184	405	6.0	289	203	1498	1863
2001	7.4	852	164	391	5.4	292	186	1399	1544
2002	6.6	878	172	405	5.3	296	200	1408	2003
2003	6.8	924	178	444	5.0	297	197	1379	2205
2004	7.3	912	175	441	4.7	291	201	1355	2175
2005	6.9	950	177	460	4.4	309	207	1466	2320
2006	6.7	959	171	457	4.0	327	198	1422	2025
2007	6.2	1 020	175	497	4.1	345	193	1768	1713
2008	5.9	1 031	169	504	3.9	354	195	1259	1440
2009	5.9	985	153	492	3.2	337	193	1327	2116
2010	4.9	958	151	488	3.1	316	194	1576	1898
2011	4.9	944	143	471	3.3	327	196	1576	1898
2012	4.9	915	133	477	2.7	302	192	1402	1974
2013	4.5	940	125	490	2.3	324	192	1218	1816
2014	4.4	949	121	464	2.0	296	187	1170	2028
2015	4.5	882	119	459	2.2	302	191	1170	2028

Year	Laying	Broilers	Turkeys	Chicken	Cocerel	Broiler hens	Other poultry
1990	4845	2993	60	1633	50	62	21
1991	4138	3250	64	1304	45	97	32
1992	3969	3506	68	1598	40	133	43
1993	4025	3763	72	1522	35	168	54
1994	4090	4020	76	1422	30	203	65
1995	4179	4276	80	1482	25	240	75
1996	4184	4052	96	1246	25	279	54
1997	4152	4911	112	1288	32	299	33
1998	3802	5507	145	1185	30	347	35
1999	3361	5998	210	1025	17	382	39
2000	3110	7918	215	914	18	364	32
2001	3202	5412	455	1043	12	394	35
2002	3213	5766	531	772	9	402	41
2003	3016	6050	603	931	10	346	40
2004	3069	5573	535	912	10	287	18
2005	3128	5472	495	954	12	287	20
2006	3103	5366	493	844	13	391	15
2007	3134	5074	431	764	13	369	24
2008	3190	5675	415	865	19	339	19
2009	2926	4918	306	859	15	329	16
2010	3394	4616	280	838	14	433	12
2011	3304	5421	308	745	22	421	14
2012	3173	6038	295	743	27	471	14
2013	3432	6861	274	857	22	520	13
2014	3645	7341	292	714	25	544	15
2015	3501	6839	248	662	25	548	23

7.2.3 Uncertainty and time series' consistency

The time series is consistent. The results of the uncertainty analysis are provided in Annex 7 of the IIR.

7.2.4 Source-specific QA/QC and verification

Normal statistical quality checks related to the assessment of magnitude and trends have been carried out. At present, no verification has been carried out for the specific source-sector emissions. Cross-checking of data and functions of the model are carried out as the same model is used both by SYKE for air pollutant emissions inventories and by LUKE for greenhouse gas emissions inventories.

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

2009

- The agriculture emissions calculation model was used for the first time in the ammonia emissions inventory in the submission in 2009.

2011

- The allocation of boars was changed from NFR 4B13 to 4B8.
- NH3 and particle emissions were recalculated and reported in NFR format.

2013

- The time series 1990-2013 was recalculated and reported in NFR14 format.

2014

- Revision of ammonia emission factors and disaggregation of activity data in cooperation with the Natural Resources Institute Finland.

2015

- Particulate matter emission factors for manure management revised according to Guidebook 2013 for the whole time series. Also data on grazing times, manure handling systems and indoor/outdoor times were updated according to domestic studies.

2017

- Particle emissions from heifers were inserted in the time series as they were missing due to an error from inventory submissions in 2010-2014.

2016-2017

- The agriculture emissions calculation model was completed with NMVOCs according to Guidebook 2016. (Munther et al., 2017)
- The calculation of NH3 and NOx emissions was revised (Grönroos et al, 2017)

7.2.6 Source-specific planned improvements

Planned for the 2018 submission

Particle emissions will be included in the agriculture emissions calculation model.

Agricultural Soils (NFR 3D)

Figure 5.7 I.K. Inha (1899)

The results of the revised calculation model for agricultural emissions were included in the 15 March 2017 resubmission. Documentation of the revised method is presented below.

7.3.1 Source category description

Changes in chapter	
Update of emission figures	April 2017 JMP
Update of text	April 2017 JMP, KS
Changes in methodology	2009, 2017
Recalculations	2016-2017
Other (e.g. language, layout)	April 2017 KS

The category covers emission sources presented in Table 5.18

Table 5.18 Emission sources and emissions reported under NFR 3D

NFR		Emissions
3Da1	Inorganic N-fertilizers	NOx, NMVOC, NH3, particles
3Da2a	Animal manure applied to soils	NOx, NMVOC, NH3
3Da2b	Sewage sludge applied to soils	NH3
3Da2c	Other organic fertilisers applied to soils	NA
3Da3	Urine and dung deposited by grazing animals	NOx, NMVOC, NH3
3Da4	Crop residues applied to soils	NA
3Db	Indirect emissions from managed soils	
3Dc	Farm-level agricultural operations including storage, handling and transport of agricultural products	particles
3Dd	Off-farm storage, handling and transport of bulk	NA
3De	Cultivated crops	NMVOC
3Df	Use of pesticides	HCB
3F	Field burning of agricultural residues	NOx, NMVOC, Sox, CO, NH3, particles heavy metals, PCDD/F, PAH-4
3I	Agriculture other	NO

7.3.2 Methodological issues

Synthetic N-fertilizers (NFR 3D1a)

Changes in chapter	
Update of emission figures	April 2017 JMP
Update of text	April 2017 KS & JMP
Change in methodology	2010 , 2015, 2017
Other (e.g. language. layout)	April 2017 KS

Ammonia emissions

Calculation of NH_3 emissions from application of nitrogen fertilizers is carried out in the agriculture emissions calculation model (Grönroos et al.. 2009, 2015). The calculation is consistent with EMEP/EEA Guidebook 2007 and uses national emission factors (Grönroos *et al* 2009).

Activity data for the calculation of emissions from agricultural soils is received from Yara Finland Ltd. (Brenback, 2016) and the Yearbook of Farm Statistic (TIKE, 2016).

Ammonia emissions due to the use of mineral N-fertilizers (Table 5.19) are calculated separately for the different fertilizer types using emission factors derived from those in the EMEP/EEA Emission Inventory Guidebook (EEA, 2007). The total amount of nitrogen sold annually is divided by fertilizer type using information (sales statistics) obtained from Yara Finland Ltd. Furthermore, the use of different mineral N-fertilizers is allocated between arable and grassland soils according to the agricultural land use statistics from the Information Centre of the Ministry of Agriculture and Forestry (Table 5.20). In Finland, placement fertilization is typically used for cereals. Based on the emission reduction efficiencies of the different manure applications and emission abatement methods, it is assumed that placement fertilization reduces ammonia volatilization by 50% compared to surface application of mineral fertilizers. Thus, emission factors for arable land are multiplied by 0.5 except for nitrogen solutions for which placement fertilization is not used.

The detailed description of the calculation is presented in Grönroos et al., 2009 available at https://helda.helsinki.fi/handle/10138/38030.

Table 5.19. Use of mineral N-fertilizers as N (tonnes) 1980-2015

Year	Use of N-fertlizer (t)	Year	Use of N-fertlizer (t)	Year	Use of N-fertlizer (t)
1980	189 098	1993	168 199	2005	149 562
1981	188 457	1994	169 138	2006	148 161
1982	177 234	1995	195 460	2007	148 784
1983	206 665	1996	179 529	2008	162 905
1984	202 814	1997	169 345	2009	136 009
1985	196 242	1998	169 928	2010	156 523
1986	194 304	1999	162 700	2011	146 189
1987	204 140	2000	167 276	2012	138 900
1988	205 674	2001	165 621	2013	138 136
1989	205 862	2002	160 403	2014	147 373
1990	228 470	2003	159 288	2015	143 479
1991	202 462	2004	154 708		
1992	163 229				

Table 5.20. Distribution of mineral N-fertilizers used in Finland by fertilizer type (%). distribution of each fertilizer type by application target (arable or grassland. %). and emission factors (EF) for different fertilizer types applied on arable and grassland. (Grönroos et al., 2009)

Spread as:	% of applied N	On arable land. %	On grassland. %	EF arable. %	EF grass. %
Ammonium sulphate	0.0	65	35	1.5	1.5
Ammonium nitrate	0.0	65	35	0.6	1.6
Calcium ammonium nitrate	19.6	65	35	0.6	1.6
Anhydrous ammonia	0.0	65	35	2.0	2.0
Urea	0.0	65	35	11.5	23.0
Nitrogen solutions[1)]	0.04	100	0	7.0	7.0
Ammonium phosphates	0.13	65	35	1.5	1.5
Other NK and NPK	80.2	65	35	0.6	1.6
Nitrate only	0.05	65	35	0.5	0.5

[1)] Nitrogen solutions are not used on grasslands. Because solutions are applied with sprayers. no emission correction factor due to placement fertilization is used.

Particle emissions

Particle emissions (TSP, $PM_{2.5}$, PM_{10}) are generated from grain fields harvesting and field preparation. Information on the use of cultivated area (Table 5.211) is obtained from TIKE (Information Centre of the Ministry of Agriculture and Forestry) (TIKE, 2014). The emissions factors from TNO (2002) are presented in Table 5.22.

Table 5.21. Annual crop yield (km2) 1990-2015

Year	Crop yield (km^2)	Year	Crop yield (km^2)	Year	Crop yield (km^2)
1990	12 505	2000	11 730	2010	9 515
1991	10 355	2001	11 472	2011	10 423
1992	9 360	2002	11 960	2012	10 364
1993	9 389	2003	11 928	2013	11 102
1994	9 477	2004	11 271	2014	11 666
1995	9 782	2005	11 858	2015	10 173
1996	10 794	2006	11 503		
1997	11 177	2007	11 315		
1998	11 570	2008	11 938		
1999	11 340	2009	11 330		

Table 5.22. Emission factors for particle emissions from grain fields (TNO, 2002).

Sector	Emission factor ($kg/km^2/a$. t/t)			Reference
	TSP	PM10	PM2.5	
harvesting	0.97	0.44	0.0078	TNO. 2002
field preparation	190	40	8.1	TNO. 2002

Nitric oxide emissions

Nitric oxide emissions were included to the inventory for first time in years 2017 submission for whole time series (1990-2015). The calculation is carried out in the Nitrogen model (Grönroos et al., 2009, 2015). Nitrogen model is described more detailed above (ammonia emissions), nitric oxide emissions are calculated in the model as part of nitrogen emissions. In the calculation an assumption of 0.7 % NO-N from synthetic fertilizers has been used and use of mineral fertilizers as N (tonnes) in a year.

Animal manure applied to soils (NFR 3Da2a)

Changes in chapter	
Update of emission figures	January 2017 JMP
Update of text	April 2017 JM, JMP,KS
Change in methodology	none
Other (e.g. language. layout)	April 2017 KS

NMVOC

Calculation of NMVOC emissions from field application of manure follows the same principle than emissions from manure storage reported under NFR 3 B. The method is based on EMEP/EEA Emission Inventory Guidebook 2016.

$$E_{manure_{application}} = E_{NMVOC_{house}} * \left(\frac{E_{NH3_{application}}}{E_{NH3_{building}}}\right)_i$$

Where,

i = Livestock category

$E_{NMVOC_{house}}$ = NMVOC emissions from housing

$E_{NH3_{application}}$ = Ammonia emissions from application

$E_{NH3_{building}}$ = Ammonia emissions from housing

Sewage sludge applied to soils (NFR 3Da2b)

Changes in chapter	
Update of emission figures	January 2017 JMP
Update of text	April 2017 JMP, KS
Change in methodology	none
Other (e.g. language. layout)	April 2017 KS

Sewage sludge application to soils has been included in the inventory since the submission in 2013. NH3 emissions are calculated in the agriculture emissions calculation model.

It is assumed (Grönroos J., 2013) that 15 % of total nitrogen is in the form of ammonium nitrogen and that 15 % of that ammonium nitrogen evaporates during the spreading on the fields.

Annual nitrogen input from sewage sludge is presented in Table 5.23 (Finland's NIR 2017, Table 5.4-4)

Table 5.23. N input from sewage sludge 1990-2015 (Mg N/year)

Year	N input from sewage sludge (Mg N/year)	Year	N input from sewage sludge (Mg N/year)	Year	N input from sewage sludge (Mg N/year)
1990	2 202	2000	513	2010	338
1991	1 749	2001	725	2011	148
1992	1 532	2002	616	2012	245
1993	1 404	2003	754	2013	223
1994	2 063	2004	441	2014	81
1995	1 316	2005	143	2015	81*
1996	1 548	2006	156		
1997	1 696	2007	147		
1998	575	2008	257		
1999	644	2009	266		

- not data available for 2015, therefore 2014 value has been used instead

Other organic fertilizers applied to soils (NFR 3Da2c)

Changes in chapter	
Update of emission figures	January 2017 JMP
Update of text	April 2017 JMP, KS
Change in methodology	none
Other (e.g. language. layout)	April 2017 KS

Emissions from application of other organic fertilizers applied to soils are reported as NA in Finland's inventory. In Guidebook 2016 methods are presented for NH3 and NOx from organic fertilisers, other than livestock manures and sewage sludge, applied to soils (including digestate and compost). It is assumed based on the national expert estimate (Grönroos, J., 2017) that digestate or compost fertilizers are not used in Finland.

The need to change the notation key to NO will be verified to the next submission.

Urine and dung deposited by grazing animals (NFR 3Da3)

Changes in chapter	
Update of emission figures	January 2017 JMP
Update of text	April 2017 JM, JMP, KS
Change in methodology	none
Other (e.g. language. layout)	April 2017 KS

NMVOC

Emissions from outdoors grazing of animals are calculated by gross feed intake (cattle) and volatile solids (other livestock) with an estimate of the time spent outdoors. The time animals spend indoors is estimated annually. The estimates are retrieved from the Finnish Normative Manure System. The emission factors in Table 5.24 are from Guidebook 2016.

Cattle:

$$E_{graz} = MJ_i * (1 - X_{house_i}) * EF_{graz_i}$$

Other livestock:

$$E_{graz} = VS_i * (1 - X_{house_i}) * EF_{graz_i}$$

where,

i = Livestock category

MJ_i = Gross feed intake as (MJ/a)

VS_i = Volatile solids excreted (kg/a)

EF_{graz_i} = Emission factor for grazing presented in Table 5.x

X_{house_i} = annual proportion of time the animal spends inside a livestock building (%)

Table 5.24. NMVOC emission factors for grazing animals (Source Guidebook 2016)

NFR	Livestock	$EF_{grazing}$	Unit
3B1a	Dairy cattle	6,90E-06	kg NMVOC kg/MJ feed intake
3B1b	Non-dairy cattle	6,90E-06	kg NMVOC kg/MJ feed intake
3B2	Sheep	2,35E-05	kg NMVOC/kg VS excreted
3B4a	Buffalo	2,35E-05	kg NMVOC/kg VS excreted
3B4d	Goats	2,35E-05	kg NMVOC/kg VS excreted
3B4e	Horses	2,35E-05	kg NMVOC/kg VS excreted
3B4f	Mules and Asses	2,35E-05	kg NMVOC/kg VS excreted
3B4h	Other animals (reindeer)	2,35E-05	kg NMVOC/kg VS excreted

Crop residues applied to soils (NFR 3Da4)

Changes in chapter	
Update of text	January 2017 JMP, KS

Emissions from crop residues applied to soils are reported as NA, because no methodology is presented in Guidebook 2016.

Indirect emissions from managed soils (NFR 3Db)

Changes in chapter	
Update of text	January 2017 JMP, KS

Indirect emissions from managed soils are reported as NA, because no methodology is presented in Guidebook 2016.

Farm-level agricultural operations including storage, handling and transport of agricultural products (NFR 3Dc)

Changes in chapter	
Update of emission figures	March 2017 JMP
Update of text	April 2017 KS & JMP
Change in methodology	none
Reallocation of particles	2009
Other (e.g. language. layout)	April 2017 KS

Particles

Particle emissions are generated from storage and handling of potassium, nitrogen and phosphorus fertilizers as well as from storage and handling of barley, oats, peas, ryes and wheat. Emissions from storage and handling of agricultural crops were earlier erroneously reported under SNAP 090700(NFR 6C but have been reallocated to NFR 3Dc (storage, handling and transport of agricultural products) since the 2009 submission, for whole time series.

Information on the use of crops yield are obtained from TIKE (Information Centre of the Ministry of Agriculture and Forestry) (TIKE, 2016) and on the amount of sold fertilizers from Yara Finland Ltd. (2016). The emissions factors from TNO are presented in Table 5.25.

Table 5.25. Emission factors for particle emissions from grain fields (TNO, 2002).

Sector	Emission factor (kg/km^2/a. t/t)			Reference
	TSP	PM10	PM2.5	
Storage and handling of K-fertilizers	0.0001	0.000032	0.000004	TNO. 2002
Storage and handling of N-fertilizers	0.0001	0.000032	0.000004	TNO. 2002
Storage and handling of P-fertilizers	0.0001	0.000032	0.000004	TNO. 2002
Storage and handling. barley	0.0001	0.000025	0.000004	TNO. 2002
Storage and handling. oats	0.0001	0.000025	0.000004	TNO. 2002
Storage and handling. peas	0.0001	0.000025	0.000004	TNO. 2002
Storage and handling. rye	0.0001	0.000025	0.000004	TNO. 2002
Storage and handling. wheat	0.0001	0.000025	0.000004	TNO. 2002

Off farm storage, handling and transport of bulk agricultural products (NFR 3Dd)

Changes in chapter	
Update of text	January 2017 JMP, KS

Emissions from off-farm storage, handling and transport of bulk agricultural products are reported as NA, because no methodology is presented in Guidebook 2016.

Cultivated crops (NFR 3De)

Changes in chapter	
Update of emission figures	January 2017 JMP
Update of text	April 2017 JM, JMP, KS
Change in methodology	none
Other (e.g. language. layout)	April 2017 KS

NMVOC

NMVOC emissions from cultivated crops such as cereals, grasslands and silage are included in the inventory. Table 5.26 presents cultivated land areas by species included in the inventory. The total cultivated land area for 2015 was 2241 hectares.

Table 5.26. Total cultivated land area per species (thousands of hectares)

Species	Cultivated area	SNAP
Wheat	249	100102
Rye	32	100102
Barley	513	100102
Oats	307	100102
Mixed grain	36	100102
Other grains	3	100102
Peas	12	100102
Potatoes	22	100102
Sugar beet	13	100102
Turnip rape and rape	57	100102
Hay	86	100105
Silage	492	100105
Pasture	58	100105
Other grassland	16	100105
Other crops	75	100104
Fallow	271	100101
Total	2 241	

The methodology for the calculation is based on EMEP/EEA Guidebook 2016 Tier 2 method, which reproduces the calculation of Tier 1 emission factor of by substituting the estimation of NMVOC Tier1 emission factor in kg ha-1 a-1 with national data. The recalculation is done for each year independently taking into account the annual relative changes within crop distribution and mean dry matter.

Default emission factor for Tier 1 calculation is 0.86 kg of NMVOC per hectare. The Tier 2 emission factor is calculated annually with the equation presented below.

$$EF_j = \sum \left(\mathrm{E}_{\mathrm{i,NMVOC}} * 24 * 365 * Frac_{emit,i} \right) * m_{dm_i} * Frac_{i,j}$$

Where,

i	= Crops species
j	= Active year
$\mathrm{E}_{\mathrm{j,NMVOC}}$	= Hourly emission flux of NMVOC per species (kg/dm^3/h)
$Frac_{emit}$	= Fraction of the year during which the species is emitting
m_{dm}	= Mean dry matter of crop (kg/ha/a)
$Frac_{i,j}$	= Fraction of species j in relation to the total of cultivated areas and fallows for the year i

The Guidebook presents default values for calculation of the EF (Table 5.27). These defaults are used whenever national data is not available, and replaced if more detailed information is available.

Table 5.27. Default values for emission factor calculation

Species (i)	Ej,NMVOC	Fracemit	mdm,	Fracij
Wheat	2.60E-8	0,3	4700	0,35
Rye	1.41E-7	0,3	2800	0,05
Rape	2.02E-7	0,3	2500	0,1
Grass (15 C)	1.03E-8	0,5	9000	0,25
Grass (25 C)	4.67E-8	0,5	9000	0,25

Mean dry matter is derived from national statistics of species-specific yields per hectare by estimating their share of dry matter. Yield mean dry matter content remains constant throughout all years. Statistical data for yield per hectare is available for 2000-2015. The values for the year 2015 are presented in Table**Error! Reference source not found.** 5.28.

Table 5.28. Yields per hectare and dry matter of 2015 in Finland

Species	Yield per hectare (kg/ha)	Yield mean dry matter content (kg/kg)	Mean dry matter mdm (kg/ha)
Wheat	4100	0,86	3526
Rye	3420	0,86	2941,2
Barley	3470	0,86	2984,2
Oats	3480	0,86	2992,8
Mixed grain	3020	0,86	2597,2
Other grains	3020	0,86	2597,2
Peas	2130	0,86	1831,8
Potatoes	24310	0,22	5348,2
Sugar beet	32740	0,23	7530,2
Turnip rape and rape	1540	0,92	1416,8
Hay	3760	0,86	3233,6
Silage	15670	0,25	3917,5
Pasture	15670	0,2	3134
Other grassland	15670	0,2	3134
Other crops	9000	0,22	1980
Fallows	7835	0,21	1645,35

Table 5.29 presents the total cultivated area as thousands of hectares for all species accompanied with the calculatory crop distribution (from the total of 2 241 000 hectares including fallows and other grasslands). Emission factors are presented in Table 5.29.

Table 5.29. Weighed emission factor and crop distribution of the year 2015, and NMVOC flux per for the main cultivated species.

Species	Cultivated area (1 000 ha)	Crop distribution (%)	NMVOC (kg/dm/a)	Weighted EF (kg NMVOC / ha / a)
Wheat	248,8	11,1 %	0.00007	0.02670
Rye	31,6	1,4 %	0.00037	0.01530
Barley	512,5	22,9 %	0.00007	0.04650
Oats	306,5	13,7 %	0.00053	0.21700
Mixed grain	36,4	1,6 %	0.00007	0.00288
Other grains	2,5	0,1 %	0.00007	0.00020
Peas	12,3	0,5 %	0.00007	0.00069
Potatoes	22,1	1,0 %	0.00007	0.00360
Sugar beet	12,5	0,6 %	0.00007	0.00286
Turnip rape and rape	56,8	2,5 %	0.00053	0.01900
Hay	85,7	3,8 %	0.00005	0.00558
Silage	492,3	22,0 %	0.00005	0.03880
Pasture	58	2,6 %	0.00005	0.00366
Other grassland	16,4	0,7 %	0.00005	0.00103
Other crops	75,1	3,4 %	0.00005	0.00299
Fallows	271,3	12,1 %	0.00005	0.00898

Table 5.30. Finnish NMVOC emission factors of cultivated crops in 5-year intervals

Year	1980	1985	1990	1995	2000	2005	2010	2015
Total Cultivated Area	2372	2276,4	2271	2141,3	2186,8	2234,6	2253,3	2240,9

Emission Factor	0,482	0,470	0,513	0,431	0,477	0,399	0,358	0,396

Use of pesticides (NFR 3Df)

Changes in chapter	
Update of emission figures	March 2017 JMP
Update of text	April 2017 KS & JMP
Change in methodology	none
Other (e.g. language. layout)	April 2017 KS

NH3

In the Guidebook 2016 version calculation of ammonia emissions from ammonia treated straw is presented. In Finland straw is neither treated with ammonia nor urea, therefore NH3 emissions from this category are reported as NA.

HCB emissions

During the manufacture of chlorine containing pesticides HCB may be formed as a by-product and part of this may be left in the product as an impurity (Jones. 2005). Pesticides where HCB can exist as impurity include Lindane, Dacthal (DCPA), Pentachlorophenol, Atrazine, Simazine. Picloram, Pentachloronitrobenzene (PCNB, quintozene), Chlorothalonil, Endosulfan and Clopyralid (Jones, 2005; Environment Canada. 2006).

It is assumed that all HCB residues in the pesticides are emitted to the air, which might be considered as an overestimation.

The HCB impurity concentrations in certain pesticides have been used as emission factors (**Error! Reference source not found.**31) and the sales of the effective substance (Evira Finnish Food Safety Authority, 2016) in pesticides as activity data. Sales information provided by Evira has been claimed confidential since the year 2009 and cannot therefore be published.

Lindane, Dacthal, PCNB and Picloram were not used in Finland during the period 1990-2014. A new herbicide containing clopyralid was put on the market in Finland in 2010.

Table 5.31. Pesticides containing HCB (Environment Canada. 2006).

Selected Pesticide Active Ingredient	Pesticide type	Concentration of HCB impurity in the pesticide (ppm or mg/kg)
Atrazine	Herbicide	1 ppm
Chlorothalonil	Fungiside	10 ppm
Clopyralid	Herbicide	2.5 ppm
Dacthal (Chlorthan Methyl. DCPA)	Herbicide	40 ppm
Endosulfan	Insecticide	0.1 ppm
Lindane	Insecticide	1 ppm
Pentachloronitrobenzene (PCNB = quintozene)	Fungiside	500 ppm
Picloram	Herbicide	8 ppm
Simazine	Herbicide	1 ppm

The emission factor for HCB emissions (0.5) from fungicides presented in Guidebook 2016 was considered to be inaccurate compared to the emission factors currently in use in the inventory (presented above) as they are available for each active ingredients.

HCB emissions are presented in Table 5.32

Table 5.32. HCB emissions from agriculture (Mg)

Year	HCB	Year	HCB	Year	HCB	Year	HCB
1980	NE	1990	1.2	2000	0.01	2010	0.032
1981	NE	1991	1.1	2001	0.01	2011	0.052
1982	NE	1992	0.78	2002	0.012	2012	0.036
1983	NE	1993	0.78	2003	0.012	2013	0.014
1984	NE	1994	0.034	2004	0.012	2014	0.022
1985	NE	1995	0.020	2005	0.010	2015	0.014
1986	NE	1996	0.011	2006	0.008		
1987	NE	1997	0.01	2007	0.006		
1988	NE	1998	0.012	2008	0.008		

1989	NE	1999	0.01	2009	0.010		

7.3.3 Uncertainty and time series' consistency

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

7.3.4 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. At present, no verification has been carried out for the specific source-sector emissions.

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

None.

7.3.6 Source-specific planned improvements

- Organic fertilizers applied to soils: The need to change the notation key to NO will be verified to the next submission.

7.4 Field burning of agricultural wastes (NFR 3F)

Changes in chapter	
Update of emission figures	March 2017 JMP
Update of text	April 2017 KS & JMP
Change in methodology	2016, 2017
Other (e.g. language. layout)	April 2017 KS

7.4.1 Source category description

Field burning of crop residues is a source of NH_3, NO_x, CO, SO_x, NMVOC, particle and heavy metal emissions. Also PCDD/F and PAH emissions are included in the inventory.

7.4.2 Methodological issues

Emissions from cereal straw (wheat, barley, oats. rye) burning were included into the inventory for first time in the submission in 2009. Calculation of emissions from field burning of agricultural waste was revised for the 2016 submission due to update of emission factors according to Guidebook 2016 and new studies that improved the activity data. Calculation of heavy metal emissions from field burning of agricultural waste was revised for the 2017 submission due to inclusion of emission factors from Guidebook 2016.

Activity data
In Finland, burning of agricultural residues occurs only at small scale and it is becoming increasingly rare. Straw is assumed to be the most important agricultural residue burned.

According to the Decree 189/2009 of the Ministry of Agriculture and Forestry field burning of crop residues has to be avoided and is allowed only if it is necessary in order to succeed in sowing or to prevent weeds or pests. According to several agricultural experts residue burning on fields occurs only in small scale in

Finland and is becoming increasingly rare. The machinery is usually able to manage the excess straw left on fields after harvesting. Cereal (especially rye) straw is the most important crop residue that may be burned on fields. Straw is mainly left on field but a minor part is used for feed or as litter in animal shelters or burning in boilers.

The annual crop yields for cereals and other crops are based on data from the Yearbook of Agricultural Statistics and the areas for cultivated cereals were also obtained from TIKE (the Information Centre of the Ministry of Agriculture and Forestry). The share of burned residue from total cereal residue on the fields for the years 1990-2013 was re-evaluated and simplified. The situation of residue burning for years 2013 (0.9%) and 2012 (0.7%) is rather accurately known as TIKE made an inquiry to the farmers.

The situation in the beginning of the 1990's is, however, still highly uncertain. Most likely, burning has been more common than nowadays and an expert opinion (Ansalehto, 2007) supports this. Therefore, field burning in the year 1990 was estimated to be twice as much as the average of years 2012 and 2013 and was assumed to rise linearly from year 2012 backwards.

Estimates for the burned fraction of cereal are presented in Table 5.33 and emission factors from Guidebook 2016 for wheat and other grains (barley, oats, ryes) in Table 5.34.

Table 5.33. Estimates of the burned fraction. Fraction of total residue burned is calculated by dividing the burned straw with total residue of all crops (as dry matter) (Finland's NIR 2017 Table 5.5-2)

Year	Frac of residue burned, cereals	Frac of residue burned, total residue
1990	0.016	0.008
1995	0.014	0.007
2000	0.012	0.007
2005	0.010	0.005
2006	0.009	0.006
2007	0.009	0.005
2008	0.009	0.006
2009	0.008	0.005
2010	0.008	0.004
2011	0.007	0.004
2012*	0.007	0.004
2013*	0.009	0.005
2014	0.008	0.005
2015	0.008	0.005

*an estimate based on TIKE inquiry

Table 5.35. Emission factors for field burning of agricultural waste (Guidebook 2016)

Pollutant	EF (wheat)	EF (other grains)	Unit
NH_3	0.0024	0.0024	kg/kg dry matter
NOx	0.0023	0.0027	kg/kg dry matter
CO	0.0667	0.0987	kg/kg dry matter
NMVOC	0.0005	0.0117	kg/kg dry matter
SO_x	0.0005	0.0001	kg/kg dry matter
PCDD/F	0.500	0.500	µg-TEQ/t /Guidebook 2013
benzo(a) pyrene	67.7	98.8	mg/kg dry matter
benzo (b) fluoranthene	189.1	307.4	mg/kg dry matter
benzo(k) fluoranthene	80.7	77.0	mg/kg dry matter
indeno(1,2,3-cd) pyrene	57.9	38.2	mg/kg dry matter
Pb	0.11	0.0036	mg/kg dry matter
Cd	0.88	0.24	mg/kg dry matter
Hg	0.14	0.096	mg/kg dry matter
As	0.064	-	mg/kg dry matter
Cr	0.08	0.14	mg/kg dry matter
Ni	0.052	0.011	mg/kg dry matter
Se	0.02	0.039	mg/kg dry matter
Zn	0.56	0.49	mg/kg dry matter
TSP	0.0058	0.0078	kg/kg dry matter
PM10	0.0057	0.0077	kg/kg dry matter
PM2.5	0.0054	0.0074	kg/kg dry matter

BC	500	1200	mg/kg dry matter

Nitrogen dioxide and carbon monoxide emissions
The emissions are calculated with emission factors in Table 5.35.

Ammonia, NMVOC, sulphur dioxide, PCDD/F, PAH-4
The emissions are calculated with emission factors in Table 5.35.

Particle and heavy emissions
Particle emissions in Table 5.36 and heavy metal emissions in Table 5.37 are calculated with emission factors in Table 5.35.

Table 5.36 Particle emissions from NFR 3F

Year	TSP	PM_{10}	$PM_{2.5}$	BC	NO_X	CO	SO_x	NMVOC	PCDD/F	B(a)P	B(b)F	B(k)F	I(1,2,3-cdP
	Gg	Gg	Gg	Gg	Gg	Gg	Gg	Gg	g I-Teq	t	t	t	t
1980	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1981	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1982	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1983	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1984	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1985	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1986	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1987	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1988	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1989	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
1990	0.305	0.301	0.287	0.037	0.113	3.694	0.015	0.253	0.023	0.004.	0.011	0.004	0.002
1991	0.277	0.273	0.261	0.034	0.103	3.352	0.013	0.226	0.021	0.003.	0.010	0.003	0.002
1992	0.230	0.227	0.216	0.028	0.085	2.786	0.011	0.191	0.017	0.003.	0.008	0.003	0.002
1993	0.286	0.282	0.269	0.035	0.106	3.469	0.014	0.239	0.021	0.003.	0.010	0.003	0.002
1994	0.276	0.272	0.259	0.034	0.102	3.342	0.013	0.233	0.020	0.003.	0.010	0.003	0.002
1995	0.254	0.251	0.239	0.031	0.094	3.080	0.012	0.211	0.019	0.003.	0.009	0.003	0.002
1996	0.276	0.271	0.259	0.033	0.102	3.327	0.014	0.217	0.021	0.003.	0.010	0.003	0.002
1997	0.273	0.269	0.257	0.033	0.101	3.303	0.013	0.225	0.020	0.003.	0.010	0.003	0.002
1998	0.202	0.199	0.190	0.024	0.075	2.433	0.010	0.153	0.015	0.002.	0.007	0.002	0.002
1999	0.193	0.190	0.182	0.024	0.071	2.342	0.009	0.166	0.014	0.002.	0.007	0.002	0.001
2000	0.270	0.265	0.253	0.032	0.100	3.249	0.014	0.206	0.020	0.003.	0.010	0.003	0.002
2001	0.235	0.231	0.221	0.028	0.087	2.832	0.012	0.180	0.018	0.003.	0.008	0.003	0.002
2002	0.241	0.237	0.226	0.028	0.090	2.892	0.013	0.170	0.018	0.003.	0.009	0.003	0.002
2003	0.225	0.222	0.211	0.026	0.084	2.702	0.012	0.160	0.017	0.003.	0.008	0.003	0.002
2004	0.224	0.220	0.210	0.026	0.084	2.690	0.012	0.164	0.017	0.003.	0.008	0.003	0.002
2005	0.222	0.219	0.209	0.027	0.083	2.689	0.011	0.179	0.017	0.003.	0.008	0.003	0.002
2006	0.199	0.196	0.187	0.024	0.074	2.401	0.010	0.161	0.015	0.002.	0.007	0.002	0.001
2007	0.215	0.212	0.202	0.026	0.080	2.596	0.011	0.163	0.016	0.003.	0.008	0.003	0.002
2008	0.211	0.208	0.198	0.025	0.078	2.544	0.010	0.166	0.016	0.003.	0.008	0.003	0.002
2009	0.205	0.202	0.193	0.025	0.076	2.480	0.010	0.165	0.015	0.002.	0.007	0.002	0.002
2010	0.137	0.135	0.129	0.016	0.051	1.648	0.007	0.098	0.010	0.002.	0.005	0.002	0.001
2011	0.160	0.157	0.150	0.018	0.060	1.912	0.009	0.107	0.012	0.002.	0.006	0.002	0.001
2012	0.157	0.154	0.147	0.018	0.059	1.881	0.009	0.108	0.012	0.002	0.006	0.002	0.001
2013	0.214	0.211	0.201	0.025	0.080	2.579	0.011	0.161	0.016	0.003	0.008	0.003	0.002
2014	0.194	0.191	0.182	0.023	0.073	2.332	0.010	0.139	0.015	0.002	0.007	0.002	0.001
2015	0.189	0.186	0.177	0.022	0.071	2.265	0.010	0.129	0.015	0.002	0.007	0.002	0.001

Table 5.37 Heavy metals from field burning of agricultural waste

	NFR 3F Heavy metals (g)								
Year	Pb	Cd	Hg	As	Cr	Cu	Ni	Se	Zn
1980	NE	NE	NE	NE	NE	NE	NE	NE	NE
1981	NE	NE	NE	NE	NE	NE	NE	NE	NE
1982	NE	NE	NE	NE	NE	NE	NE	NE	NE
1983	NE	NE	NE	NE	NE	NE	NE	NE	NE
1984	NE	NE	NE	NE	NE	NE	NE	NE	NE
1985	NE	NE	NE	NE	NE	NE	NE	NE	NE
1986	NE	NE	NE	NE	NE	NE	NE	NE	NE
1987	NE	NE	NE	NE	NE	NE	NE	NE	NE
1988	NE	NE	NE	NE	NE	NE	NE	NE	NE
1989	NE	NE	NE	NE	NE	NE	NE	NE	NE
1990	0.003	0.027	0.005	0.000	0.005	0.002	0.002	0.001	0.024

1991	0.003	0.025	0.005	0.000	0.004	0.002	0.001	0.001	0.022
1992	0.002	0.020	0.004	0.000	0.004	0.001	0.001	0.001	0.018
1993	0.003	0.025	0.005	0.000	0.005	0.002	0.001	0.001	0.023
1994	0.002	0.024	0.005	0.000	0.004	0.002	0.001	0.001	0.022
1995	0.002	0.022	0.005	0.000	0.004	0.002	0.001	0.001	0.020
1996	0.003	0.025	0.005	0.000	0.004	0.002	0.001	0.001	0.022
1997	0.003	0.024	0.005	0.000	0.004	0.002	0.001	0.001	0.022
1998	0.002	0.019	0.004	0.000	0.003	0.001	0.001	0.001	0.016
1999	0.002	0.017	0.003	0.000	0.003	0.001	0.001	0.001	0.015
2000	0.003	0.025	0.005	0.000	0.004	0.002	0.001	0.001	0.022
2001	0.002	0.022	0.004	0.000	0.004	0.002	0.001	0.001	0.019
2002	0.003	0.024	0.005	0.000	0.004	0.002	0.001	0.001	0.020
2003	0.002	0.022	0.004	0.000	0.004	0.002	0.001	0.001	0.018
2004	0.002	0.022	0.004	0.000	0.004	0.002	0.001	0.001	0.018
2005	0.002	0.020	0.004	0.000	0.004	0.001	0.001	0.001	0.018
2006	0.002	0.018	0.004	0.000	0.003	0.001	0.001	0.001	0.016
2007	0.002	0.020	0.004	0.000	0.003	0.001	0.001	0.001	0.017
2008	0.002	0.019	0.004	0.000	0.003	0.001	0.001	0.001	0.017
2009	0.002	0.019	0.004	0.000	0.003	0.001	0.001	0.001	0.016
2010	0.001	0.013	0.003	0.000	0.002	0.001	0.001	0.001	0.011
2011	0.002	0.016	0.003	0.000	0.002	0.001	0.001	0.001	0.013
2012	0.002	0.016	0.003	0.000	0.002	0.001	0.001	0.001	0.013
2013	0.002	0.020	0.004	0.000	0.003	0.001	0.001	0.001	0.017
2014	0.002	0.019	0.004	0.000	0.003	0.001	0.001	0.001	0.016
2015	0.002	0.019	0.004	0.000	0.003	0.001	0.001	0.001	0.016

7.4.3 Uncertainty and time series' consistency

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

7.4.4 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. At present, no verification has been carried out for the specific source-sector emissions.

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

The activity data for field burning has been revised for the whole time series and thus NH3 emissions have also changed.

7.4.6 Source-specific planned improvements

None.

Agriculture other (NFR 3 I)

Not occurring in Finland.

8 WASTE (NFR 5)

Changes in chapter	
Update of emission figures	March 2017 JMP
Update of text	April 2017 KS. JP. JMP
Change in methodology	none
Other (e.g. language. layout)	April 207 KS

8.1 Source category description

Emissions from solid waste disposal on land (landfills), waste incineration, waste water treatment and composting are included in this category and presented in Table 6.1. 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 2015.

NFR	Processes	Description	Emissions reported
5 A	Biological treatment of waste – Solid waste disposal on land	solid municipal, industrial, construction and demolition wastes	NMVOC
5 B 1	Biological treatment of waste - Composting	biowaste, municipal solid waste, municpal and industrial sludges and industrial solid waste	NMVOC, NH3
5 B 2	Biological treatment of waste – Anaerobic digestion at biogas facilities	several biogas reactors in Finland.	NMVOC
5 C 1 a	Municipal waste incineration		NOx, NMVOC, SOx, NH3, particles (PM2,5, PM10, TSP, BC) CO, heavy metals (Pb, Cd, Hg, As, Cr, Cu, Ni, Zn), PCDD/PCDF, PAH-4 , HCB, PCB, BC
5 C 1 bi	Industrial waste incineration		NOx, NMVOC, SOx, NH3, particles (PM2,5, PM10, TSP, BC) CO, heavy metals (Pb, Cd, Hg, As, Cr, Cu, Ni, Zn), PCDD/PCDF, PAH-4 , HCB, PCB, BC
5 C 1 bii	Hazardous waste incineration	IE	IE, included in municipal (5C1a) and industrial (5C1bi) waste incineration
5 C 1 biii	Clinical waste incineration	IE	IE included in 5C1bi
5 C 1 biv	Sewage sludge incineration	IE	IE, included in 5C1bi
5 C 1 bv	Cremation	part of emissions IE	IE (NOx, NMOVC, S0x, CO included in energy sector) particles (PM2,5, PM10, TSP, BC), heavy metals (Pb, Cd, Hg, As, Cr, Cu, Ni, Zn), PCDD/PCDF, PAH-4, PCB, BC
5 C 1 bvi	Other waste incineration	IE	IE, included in municipal (5C1a) and industrial (5C1bi) waste incineration
5 C 2	Open burning of waste	NO	Not Occuring
5 D 1	Domestic wastewater handling	wastewater handling, domestic	NMVOC, NH3 other emissions IE, the notation key must be checked to next submission
5 D 2	Industrial wastewater handling	wastewater hanglind, industrial	NMVOC other emissions IE, the notation key must be checked to next submission
5 D 3	Other wastewater handling	NA	NA,
5 E	Other waste	car and house fires unintentional landfill fires,	particles (PM2,5,PM10,TSP, BC) heavy metals (Pb, Cd, Hg, As,Cr, Cu) PCDD/PCDF, PCB

Population as reference activity data related to the waste sectors is presented in 0. The data (total population and population in urban areas 1990-2015) is provided by Statistic Finland (2017).

Table 6.2. Background data (total population and population in urban ares) related to the waste sectors in 1990-2015 (Statistic Finland, 2017).

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			
2001	5194901	3401057			
2002	5206295	3423255			
2003	5219732	3444416			
2004	5236611	3467411			
2005	5255580	3491993			

8.2 Solid waste disposal on land (NFR 5A)

Changes in chapter	
Update of emission figures	September 2017 JMP
Update of text	April 2017K S. JMP
Change in methodology	none
Other (e.g. language. layout)	April 2017 KS

8.2.1 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.

After the implementation of the new Waste Act (1994) and the Landfill Directive (1999/31/EC) 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. 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 shares of emissions for each air pollutant reported under the NFR category 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 2015.

Pollutant	Emissions from solid waste disposal on land in 2015	Total emissions in 2015	Unit	Share of total emissions %	% reported by the plants
NMVOC	0.095	87.76	Gg	0.1	0

8.2.2 Methodological issues

NMVOC emissions

NMVOC emissions from solid waste disposal on land reported in the Finnish submissions under the UNECE CLRTAP and the EU NECD are presented in Figure 6.1. As can be seen from the figure the estimates are not consistent over the years. The estimates for the 1988 and 1989 are highly overestimated. Emissions from 1990 onwards are reported also to the GHG inventory yearly. The NMVOC emissions calculated for the inventories under the UNECE CLRTAP and the EU NECD are also reported

under the UNFCCC reporting and the activity data used in the calculation are the same as used in estimation of greenhouse gases from this sector.

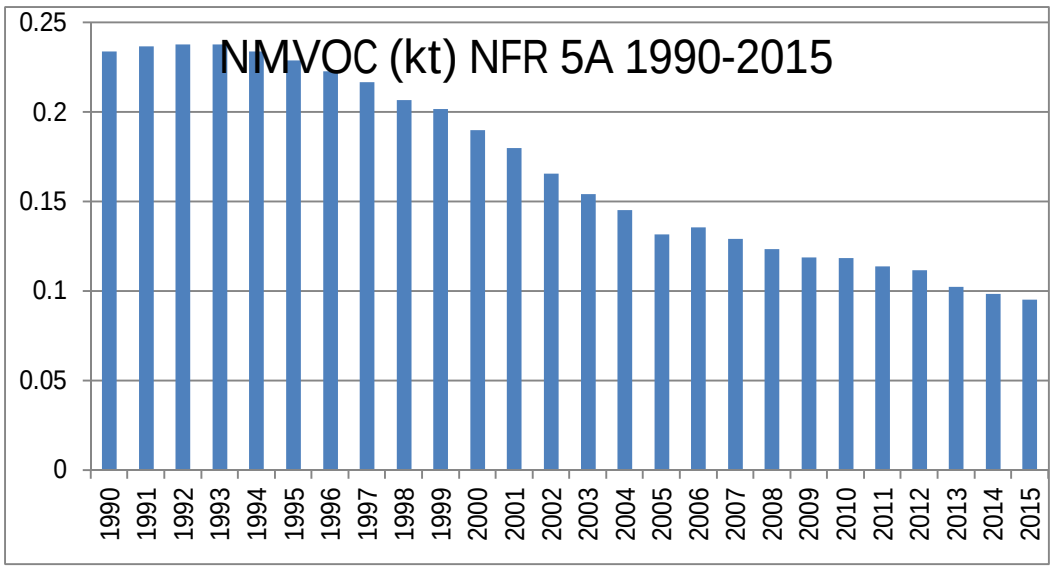


Figure 6.1. NMVOC emissions reported under NFR 5A in 1990-2015

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).

The total amount of waste taken to landfills from 1997 onwards is used as activity data in the calculation. This activity data is available in VAHTI 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 1990-2015 is presented in 0 and additional background data in Table 6.5.

Table 6.4. ***Landfilled waste*** *(1 000 t).*

Sources: VAHTI 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, 2017)

Waste group	1990	1991	1992	1993	1994	1995	1996	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				
Municipal solid waste	1095	1033	885	685	451	318				
Municipal sludge (d.m.)	3	2	3	3	2	5				
Municipal sludge (wet m.)	22	23	22	22	17	14				
Industrial sludge (d.m.)	26	27	32	32	19	7				
Industrial sludge (wet m.)	82	78	96	94	42	20				
Industrial solid waste	2661	2742	3312	3175	3074	2841				
Constr. and demol. waste	342	240	241	196	180	161				

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	%

8.3.3 Uncertainty and time series' consistency

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

8.3.4 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. At present, no verification has been carried out for the specific source-sector emissions.

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

None.

8.3.6 Source-specific planned improvements

None.

8.3 Composting (NFR 5B1)

Changes in chapter	
Update of emission figures	March 2017 JMP
Update of text	April 2017 KS. JMP
Change in methodology	2016
Other (e.g. language. layout)	April 2017 KS

8.3.1 Source category description

NMVOC and NH_3 emissions from composting are included in the category from year 1990 onwards. In the 2016 submission NMVOC emissions have been recalculated for whole time series (1990 onwards) to be consistent with UNFCCC reporting. The shares of emissions for each air pollutant reported under the NFR category are presented in Table 6.6.

Table 6.6. Contribution of Biological treatment of waste - Composting (NFR 5B1) to total emissions in 2015.

Pollutant	Emissions from composting in 2015	Total emissions in 2015	Unit	Share of total emissions %	% reported by the plants
NH3	0.101	31.85	Gg	0,3	0
NMVOC	0.05	87.76	Gg	<0.1	0

8.3.2 Emission trends

Emissions from composting have been increasing since 1990 due to the increased composting especially in semi-urban areas, which results from separate collection of organic waste.

8.3.3 Methodological issues

NMVOC emissions
NMVOC emissions are calculated from composting of waste (municipal solid waste, municipal and industrial sludge and industrial solid waste (which includes construction and demolition waste)). NMVOC emissions from composting are calculated according to the method used for landfills (biogas concentration 485 mg/m^3).

The NMVOC emissions calculated for the inventories under the UNECE CLRTAP and the EU NECD are also reported under the UNFCCC reporting and the activity data used in the calculation are the same as used in estimation of greenhouse gases from this sector.

Activity data presented in 0 and are based on VAHTI system. The activity data for composted municipal biowaste for 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. Data on 1997, 2004 and 2005 are from the VAHTI system and the intermediate years have been interpolated. In addition, composted solid biowaste in 1991 to 1996 has been interpolated using auxiliary information from the National Waste Plan until 2005 (Ministry of the Environment 1998). The new composting treatment code (R032) and composting plant code in the VAHTI system have been used in the data collection for 2006 to 2015. In 2015, the composted municipal sludges are estimated according to the removed outgoing sludges from municipal wastewater plants and the usage of sludges in anaerobic digestion plants and directly in agriculture and in landscaping. Reported data on outgoing sludges are more reliable than usage data in composting plants in most regional Centres for Economic Development, Transport and the Environment but two Centres for Economic Development, Transport and the Environment have failed several years also in reporting outgoing wastewater sludges to Vahti register and copied yearly data are used in these cases. The classification to the reporting subgroups is based on to the EWC codes of composted wastes (like landfilled wastes with the exception of construction wastes). The amounts of composted sludges have turned down after 2006. In recent years, anaerobic digestion plants have been built in Finland, which is probably the main reason for this development. (Finland's GHG NIR, 2017)

Table 6.7. Composted waste with auxiliary matter in 1990-2015 by subcategory (1000 t). (Finland's NIR, 2017)

	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				
Municipal solid waste	304	319	304	317	317	247				
Municipal sludge (d.m.)	143	137	1121	128	120	113				
Industrial sludge (d.m.)	38	33	22	22	25	25				
Industrial solid waste	60	77	47	31	35	24				

NH_3 emissions

Ammonia emissions form composting has been included to the inventory since year 2009. Emission are calculated for whole time series using an emission factor of 0.24 kg/Mg organic waste as presented in Emission Inventory Guidebook 2016. The used activity data is same as in NMVOC emission calculations and is presented in 0. In Table 6.8 is presented calculated NH_3 emissions from composting.

Table 6.8. NH_3 emissions from composting 1990-2015

Year	NH_3 emission (kt)	Year	NH_3 emission (kt)	Year	NH_3 emission (kt)
1990	0.0348	2000	0.08496	2010	0.12504
1991	0.03912	2001	0.08952	2011	0.13464
1992	0.04344	2002	0.09384	2012	0.12432
1993	0.0468	2003	0.09816	2013	0.12432
1994	0.05016	2004	0.10248	2014	0.1158
1995	0.05808	2005	0.11256	2015	0.1008
1996	0.06624	2006	0.12192		
1997	0.06936	2007	0.12768		
1998	0.07464	2008	0.12552		
1999	0.07992	2009	0.12312		

8.3.4 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 2017.

8.3.5 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.

At present, no verification has been carried out for the specific source-sector emissions.

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

None.

8.3.7 Source-specific planned improvements

None.

8.4 Anaerobic digestion at biogas facilities (NFR 5B2)

Changes in chapter	
Update of emission figures	March 2017 JMP
Update of text	April 2017 KS. JMP
Change in methodology	none
Other (e.g. language. layout)	April 2017 KS

8.4.1 Source category description

In Finland altogether 16 biogas reactor plants have been in operation at different municipal wastewater treatment plants by the end of 2013. Industrial wastewaters were treated anaerobically at three different plants. Farm-scale biogas plants were operating at 12 places. Municipal solid wastes were treated at 11 biogas plants. In 2014 the amount of biogas produced by the reactor installations was 59.1 million m³ and the combustion of surplus biogas 5.3 million m³. Production of thermal, electrical and mechanical energy was 260.8 GWh. As compared to the year 2013 there was a slight increase in the total amount of the produced biogas and the energy. There were altogether 40 landfill gas recovery plants operating at the end of 2013. The amount of the recovered biogas was 94.8 million m³. The amount of recovered biogas used for the production of electrical and thermal energy was 70.8 million m³, producing 294.9 GWh. (Huttunen M., J and Kuittinen V., 2014)

In the 2016 submission NMVOC emissions were updated from 1990 onwards to be consistent with the UNFCCC reporting.

The shares of emissions for each air pollutant reported under the NFR category are presented in **Error! Reference source not found.**

Table 6.9. Contribution of Biological treatment of waste – Anaerobic digestion at biogas facilities (NFR 5B2) to total emissions in 2015.

Pollutant	Emissions from anaerobic digestion at biogas facilities in 2015	Total emissions in 2015	Unit	Share of total emissions %	% reported by the plants
NMVOC	0.004	87.76	Gg	<0.1	0

8.4.2 Methodological issues

NMVOC emissions
NMVOC emissions from anaerobic digestion at biogas facilities are calculated according to the method used for landfills (biogas concentration 485 mg/m^3).

The NMVOC emissions calculated for the inventories under the UNECE CLRTAP and the EU NECD are also reported under the UNFCCC reporting and the activity data used in the calculation are the same as used in estimation of greenhouse gases from this sector.

Activity data is based on the VAHTI system and extrapolated data from digestion plants operation in 1990-1995 (using municipal sludges). The classification to the reporting subgroups is based on the EWC codes of treated wastes. In recent years several anaerobic digestion plants have been built in Finland which has multiplied the waste amounts as can be seen in Table 6.10.

Table 6.10. Waste amounts in anaerobic digestion by subcategory (1000 t)

	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Municipal solid waste	NO	NO	3.8	33.5	60.7	36.6	38.9	42.4	43.0	46.7	49.5	63.8	72.2	92.3	100.6	90.4	100.9	157.7
Municipal sludge (d.m.)	1.8	1.8	2.6	2.4	2.4	4.8	3.6	2.9	4.7	4.0	9.8	20.6	22.6	32.1	40.1	36.6	45.5	46.4
Industrial sludge (d.m.)	NO	NO	NO	NO	NO	0.001	0.04	0.5	0.002	NO	0.8	0.2	0.8	3.3	4.4	5.1	4.3	6.8
Industrial solid and constr. waste	NO	NO	NO	0.1	0.1	NO	1.2	5.0	30.1	54.9	44.8	41.5	66.1	61.7	64.4	75.9	77.7	79.5

8.4.3 Uncertainty and time series' consistency

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

8.4.4 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. At present. no verification has been carried out for the specific source-sector emissions.

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

None.

8.4.6 Source-specific planned improvements

None.

8.5 Waste Incineration (NFR 5C)

Changes in chapter	
Update of emission figures	March 2017 JMP
Update of text	April 2017 KS JMP
Change in methodology	none
Other (e.g. language. layout)	April 2017 KS

8.5.1 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 670.000 tonnes of municipal waste was deposited at landfills in 2013. For example in 2008 the amount was still 1.400.000 tonnes. Especially incineration of waste is on the rise (Table 6.11). There are already eight waste incineration plants that are running or being built in Finland, as well as 14 waste co-incineration plants. If the current development continues. landfills for municipal waste will become history, as is already the case in Switzerland and almost true for Sweden, Germany and Denmark. (Statistic Finland (2014) in http://www.stat.fi/til/jate/2013/jate_2013_2014-11-27_tie_001_en.html).

Table 6.11. Volume of incinerated wastes (1000 t) and number of cremated corpses in Finland

Waste and corpses burned	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Domestic and municipal wastes	60.0	70.6	74.9	76.5	91.6	84.5	81.8	114.2	142.1	196.8
Industrial wastes	4 000	4 000	4 000	4 000	4 500	5 000	5 000	5 435	7 206	4 561
Corpses	7 609	7 764	8 121	8 986	9 163	9 774	10 823	10 977	11 834	12 466
Waste and corpses burned	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Domestic and municipal wastes	221.2	229.6	189.4	222.8	235.9	226.8	222.3	310.4	360.0	463.0
Industrial wastes	5 970	5 774	5 052	4 042	7 129	6 813	7 339	7 339	7 339	7 339
Corpses	13 084	13391	14 354	14 847	15 508	16 108	16459	17 796	18 199	19 561
Waste and corpses burned	2010	2011	2012	2013	2014	2015				
Domestic and municipal wastes	463.0	679.0	679.0	679.0	1 137	1 312				
Industrial wastes	7 339	7 339	7 339	7 339	7 339	7339				
Corpses	21068	21 540	22648	23702	24822	25631				

8.6 Municipal waste incineration (NFR 5C1a)

Changes in chapter	
Update of emission figures	March 2017JMP
Update of text	April 2017 KS. JMP
Change in methodology	none
Other (e.g. language. layout)	April 2017 KS

8.6.1 Source category description

Waste incineration without energy recovery in Finland is negligible. Since 2007 there have been three operating combustion plants in Finland without energy recovery. Emission data for these plants is available in environmental reporting of plants.

The allocation of plants with waste incineration for energy production should be under the energy sector and the correctness of these allocations will be checked for the next submissions.

The shares of emissions for each air pollutant reported under the NFR category are presented in **Error! Reference source not found.**
Table 6.12.

Table 6.12. Contribution of Municipal waste incineration (NFR 5C1a) to total emissions in 2015.

Pollutant	Emissions from municipal waste incineration in 2015	Total emissions in 2015	Unit	Share of total emissions %	% reported by the plants
BC	<0.001	4.60	Gg	<0.1	0
Cd	<0.001	0.92	Mg	<0.1	37
CO	0.007	324.57	Gg	<0.1	100
Cr	0.002	15.63	Mg	<0.1	37.4
Cu	0.006	39.57	Mg	<0.1	37.5
Hg	0.001	0.64	Mg	0.2	100
NH3	<0.001	31.85	Gg	<0.1	100
Ni	0.001	16.92	Mg	<0.1	37.7
NMVOC	0.013	87.76	Gg	<0.1	74.8
NOx (as NO2)	0.223	139.68	Gg	0.2	100
Pb	0.003	13.93	Mg	<0.1	37.6
TSP	<0.001	50.02	Gg	<0.1	100
Zn	0.02	129.07	Mg	<0.1	37.5
HCB	1.316	20.94	kg	6.3	0
PCBs	6.579	151.89	kg	4.3	0
PCDD/ Fs	0.334	14.25	g I-Teq	2.3	12
PM10	<0.001	32.15	Gg	<0.1	0
PM2.5	<0.001	21.98	Gg	<0.1	0
SOx (as SO2)	0.014	42.06	Gg	<0.1	100
PAHs	0.056	9.41	Mg	0.6	4.2

8.6.2 Methodological issues

SO_2, NOx, NMVOC, NH3, particle and heavy metal emissions
Emissions are reported by the plants according to the monitoring requirements in the environmental permits. Fuel based emissions are reported in energy sector.

POP emissions
Emissions are mostly reported by the plants according to their environmental permit conditions and completed by calculated estimates as follows:

HCB emissions have been calculated with an emission factor of 1.0 mg/t (EMEP/CORINAIR Guidebook, September 2006) for plants that do not report their emissions. In Emission Inventory Guidebook 2016 an emission factor 0.002 g/t (tier 2) has been presented, the possibility to use it in next submissions will be investigated.

PCB emissions are calculated with the factor of 5.0 mg/t (EMEP/CORINAIR Guidebook, September 2005) when no emissions are reported. In Emission Inventory Guidebook 2016 an emission factor 5.3 mg/t (tier 2) has been presented, the possibility to use it in next submissions will be investigated.

PCDD/F and PAH-4 emissions are reported by plants only.

Calculated emissions from municipal waste incineration are presented in Table 6.13.

Table 6.13. Calculated emissions (HCB and PCB) in waste incineration

Year	HCB (kg)	PCB (kg)	Year	HCB (kg)	PCB (kg)
1990	0.05	0.27	2010	0.56	2.09
1991	0.06	0.32	2011	0.68	3.15
1992	0.07	0.35	2012	0.68	3.15
1993	0.08	0.42	2013	0.68	3.14
1994	0.09	0.46	2014	1.14	5.45
1995	0.09	0.46	2015	1.32	6.58
1996	0.09	0.21			
1997	0.12	0.36			
1998	0.15	0.50			
1999	0.21	0.80			
2000	0.22	0.86			
2001	0.23	0.91			
2002	0.19	0.70			
2003	0.22	0.86			
2004	0.24	0.93			
2005	0.23	0.90			
2006	0.22	0.87			
2007	0.31	1.31			
2008	0.48	2.16			
2009	0.46	2.08			

8.6.3 Uncertainty and time series' consistency

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

8.6.4 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.

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

2015

- Emissions before 2011 were corrected by removing double values: NFR 5C1a is NE (includes emissions from WWTPs), the emissions are now reported under 5D1.

2016

- Ammonia emissions in 5C1a were revised for whole time series. In previous submissions Finland has reported emissions from clinical waste incineration (NFR 5C1 biii) 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.

8.6.6 Source-specific planned improvements

None.

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

Changes in chapter	
Update of emission figures	March 2017JMP
Update of text	April 2017 KS. JMP
Change in methodology	none
Other (e.g. language. layout)	April 2017 KS

8.7.1 Source category description

The shares of emissions for each air pollutant reported under the NFR category are presented in **Error! Reference source not found.**

Table 6.14. Contribution of Industrial waste incineration (NFR 5C1bi) to total emissions in 2015.

Pollutant	Emissions from industrial waste incineration in 2015	Total emissions in 2015	Unit	Share of total emissions %	% reported by the plants
Cd	0.001	0.92	Mg	0.1	100
CO	0.009	324.57	Gg	<0.1	100
Cr	0.004	15.63	Mg	<0.1	100
Cu	0.011	39.57	Mg	<0.1	100
Hg	0.004	0.64	Mg	0.6	100
Ni	0.005	16.92	Mg	<0.1	100
NMVOC	0.038	87.76	Gg	<0.1	1.4
NOx (as NO2)	0.296	139.68	Gg	0.2	100
Pb	0.004	13.93	Mg	<0.1	100
TSP	0.001	50.02	Gg	<0.1	100
Zn	2.275	129.07	Mg	1.8	0
HCB	3.931	20.94	kg	18.8	0
PCBs	34.489	151.89	kg	22.7	0
PCDD/ Fs	0.366	14.25	g I-Teq	2.6	2.7
PM10	<0.001	32.15	Gg	<0.1	0
PM2.5	<0.001	21.98	Gg	<0.1	0
SOx (as SO2)	0.013	42.06	Gg	<0.1	100
PAHs	0.09	9.41	Mg	1	0

8.7.2 Methodological issues

SO_2. NOx. NMVOC. particle and heavy metal emissions
SO_2, NOx, NMVOC, particle and heavy metal emissions are reported by the plants according to the monitoring requirements in the environmental permits in the VAHTI database. Fuel based emissions are allocated in the energy sector.

The amount of incinerated industrial waste is available since 1990.

POP emissions
PCDD/F, PAH-4, HCB and PCB emissions reported by the plants have been completed with calculated emission data for those plants that do not report their emissions to the supervising authorities.

The following emission factors are used:
HCB 1.9 mg/t (Joas. A., 2006) (GB2016/Tier 2 0.002 g/t)
PCB 5.0 mg/t (EMEP/CORINAIR Guidebook, September 2005), (GB 2016/tier 2 EF 4.5 mg/t). The use of Guidebook 2016 emission factors will be investigated further.

PCDD/F and PAH-4 emissions are reported by plants only.

PCP
Emissions from hazardous waste incineration are based on data reported by the operators (Table 6.11). Emission factors for municipal waste incineration were derived at SYKE from emission data available from VAHTI 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.

Calculated emissions from industrial waste incineration are presented in Table 6.135.

Table 6.15. Calculated emissions (HCB and PCB) in industrial waste incineration

Year	HCB (kg)	PCB (kg)	Year	HCB (kg)	PCB (kg)
1990	2.28	20.0	2010	3.93	34.5
1991	2.28	20.0	2011	3.93	34.5
1992	2.28	20.0	2012	3.93	34.5
1993	2.28	20.0	2013	3.93	34.5
1994	2.57	22.5	2014	3.93	34.5
1995	2.85	25.0	2015	3.93	34.5
1996	2.85	25.0			
1997	3.10	27.2			
1998	3.14	36.0			
1999	2.60	22.8			
2000	3.40	29.9			
2001	3.29	28.9			
2002	2.88	25.3			
2003	2.30	20.2			
2004	4.06	35.6			
2005	3.88	34.1			
2006	4.18	36.7			
2007	4.18	36.7			
2008	3.93	34.5			
2009	3.93	34.5			

8.7.3 Uncertainty and time series' consistency

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

8.7.4 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.

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

None.

8.7.6 Source-specific planned improvements

The use of Guidebook EFs for HCB and PCB will be investigated.

8.8 Clinical waste incineration (NFR 5C1biii)

Changes in chapter	
Update of emission figures	March 2017JMP
Update of text	April 2017 KS. JMP
Change in methodology	none
Other (e.g. language. layout)	April 2017 KS

8.8.1 Source category description

Emissions from year 1994 onwards are included in NFR category 5Ca1 since 2016 submission. In 1990-2015 submissions Finland has reported emissions from clinical waste incineration (NFR 5C1 biii), 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) law and the revision of the Environmental Protection Act came into force resulting in the change that clinical waste has been managed in larger toxic waste disposal plants or landfilled after that. In 2016 landfilling has been forbidden and all clinical waste has to incinerate in waste incineration plants.

8.8.2 Methodological issues

Activity data
Activity data is an assumption based on an expert estimate (SYKE/Merilehto Kirsi, 2000). The same value of 10 000 tonnes of incinerated waste is used for all the years.

Emission factors
PCDD/F. PAH4. HCB and PCB emissions for years 1990-1993 are calculated witht he following emission factors:

- PCDD/ F 7 ug 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 (EMEP/CORINAIR Guidebook, September 2005) (GB16 0.02 g/Mg)

From 1994 onwards clinical waste has been treated in a larger toxic waste disposal plants or landfilled. From 2016 onwards clinical waste should be incinerated in larger waste combustion plants or in toxic waste disposal plants.

Calculated emissions from clinical waste incineration 1990-1993 are presented in Table 6.13.

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

Year	HCB (kg)	PCB (kg)	PCDD/PCDF (ug I-TEQ)	
1990	0.029	0.2	0.07	
1991	0.029	0.2	0.07	
1992	0.029	0.2	0.07	
1993	0.029	0.2	0.07	
Year	Benzo(a)pyrene (kg)	Benzo(b)fluoranthene (kg)	Benzo(k)fluoranthene (kg)	Indeno(1,2,3-cd) pyrene (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

8.8.3 Uncertainty and time series' consistency

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

8.8.4 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.

8.8.5 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 included although actually no incineration of clinical waste has occurred at hospital sites after the year 1993.

8.8.6 Source-specific planned improvements

None.

8.9 Cremation (NFR 5C1bv)

Changes in chapter	
Update of emission figures	March 2017JMP
Update of text	April 2017 KS. JMP
Change in methodology	none
Other (e.g. language. layout)	April 2017 KS

8.9.1 Source category description

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

Table 6.17. Contribution of Cremation (NFR 5C1bv) to total emissions in 2015.

Pollutant	Emissions from cremation in 2015	Total emissions in 2015	Unit	Share of total emissions %	% reported by the plants
Cd	<0.001	0.92	Mg	<0.1	0
Cr	<0.001	15.63	Mg	<0.1	0
Cu	<0.001	39.57	Mg	<0.1	0
Hg	0.015	0.64	Mg	2.4	0
Ni	<0.001	16.92	Mg	<0.1	0
Pb	<0.001	13.93	Mg	<0.1	0
TSP	<0.001	50.02	Gg	<0.1	0
Zn	0.004	129.07	Mg	<0.1	0
HCB	0.004	20.94	kg	<0.1	0
PCBs	<0.001	151.89	kg	<0.1	0
PCDD/ Fs	0.077	14.25	g I-Teq	0.5	0
PM10	<0.001	32.15	Gg	<0.1	0
PM2.5	<0.001	21.98	Gg	<0.1	0
Se	<0.001	0.44	Mg	0.1	0
PAHs	<0.001	9.41	Mg	<0.1	0

8.9.2 Methodological issues

Emissions from cremation are calculated using the amount of incinerated corpses received from the Finnish Congregations (Finnish Congregations, 2017) (0) as activity data and emissions factors presented in 0. In the earlier submissions only POP, particle and mercury emissions where calculated from cremation 1990 onwards, but in years 2013 submission also other heavy metal emissions were included to the inventory. At the moment heavy metal (except Hg) emissions are calculated only for years 2013-15 but will be will be revised for the whole time series when the recalculation of time-series will be finalized. The used emission factors for heavy metals except mercury are from EMEP/EEA Guidebook 2016. For mercury emissions emission factors presented in 0 are used.

Table 6.18. Particle (TSP,PM10, PM2,5 and BC) heavy metal (Pb, Cd, As, Cr, Cu, Ni, Se and Zn) and POP compounds (HCB, PCB, PCDD/PCDF and PAH compounds) emission factors for incineration of corpses.

Pollutant	Emission factor	Unit	Reference
TSP, PM10, PM2.5	2.53*10-5	kg/body	Finstad et al., 2003
BC	50 %	of PM2.5	Aasestad, 2013
Pb	30.03	mg/body	Guidebook, 2016
Cd	5.03	mg/body	Guidebook, 2016
As	13.61	mg/body	Guidebook, 2016
Cr	13.56	mg/body	Guidebook, 2016
Cu	12.43	mg/body	Guidebook, 2016
Ni	17.33	mg/body	Guidebook, 2016
Se	19.78	mg/body	Guidebook, 2016
Zn	160.12	mg/body	Guidebook, 2016
HCB	150	ug/t	Guidebook, 2016
PCB	400	ug/t	BiPRO, 2006
PCDD/PCDF	3	ug/I-TEQ/body	SEPA, 1996
Benzo(a)pyrene	13.2	ug/body	Guidebook, 2016
Benzo(b)fluoranthene	7.21	ug/body	Guidebook, 2016
Benzo(k)fluoranthene	6.44	ug/body	Guidebook, 2016
Indeno(1,2,3-cd) pyrene	6.99	ug/body	Guidebook, 2016

Table 6.19. Incinerated corpses 1990-2015 (Finnish Congregations) and Hg EF (Swedish IIR 2014)

Year	Incinerated corpses	EF (Hg) (kg/body)	Year	Incinerated corpses	EF (Hg) (kg/body)
1990	7610	0.00296	2006	16459	0.00076
1991	7764	0.00295	2007	17796	0.00074
1992	8121	0.00295	2008	18199	0.00071
1993	8986	0.00295	2009	19561	0.00072
1994	9163	0.00293	2010	21068	0.00071
1995	9774	0.00287	2011	21540	0.00065
1996	10823	0.00277	2012	22648	0.00059
1997	10977	0.00263	2013	23702	0.00059
1998	11834	0.00236	2014	24822	0.00059
1999	12466	00.201	2015	25631	0.00059
2000	13084	0.00168			
2001	13391	0.00102			
2002	14354	0.001			
2003	14847	0.00099			
2004	15508	0.00093			
2005	16108	0.00087			

Calculated emissions (particles (TSP, PM10, PM2.5, BC) heavy metals (Pb, Cd, As, Cr, Cu, Ni, Se, Hg and Zn) and POP compounds (HCB, PCB, dioxins and PAH compounds)) from cremation are presented in Table 6.20.

Table 6.20. Calculated emissions (particles, heavy metals and POP compounds) in cremation

Year	TSP (t)	PM10 (t)	PM2.5 (t)	BC (t)
1990	0.00019	0.00019	0.00019	0.0001
1991	0.00020	0.00020	0.00020	0.0001
1992	0.00021	0.00021	0.00021	0.0001
1993	0.00023	0.00023	0.00023	0.0001
1994	0.00023	0.00023	0.00023	0.0001
1995	0.00025	0.00025	0.00025	0.0001
1996	0.00027	0.00027	0.00027	0.0001
1997	0.00028	0.00028	0.00028	0.0001
1998	0.00030	0.00030	0.00030	0.0002
1999	0.00032	0.00032	0.00032	0.0002
2000	0.00033	0.00033	0.00033	0.0002
2001	0.00034	0.00034	0.00034	0.0002
2002	0.00036	0.00036	0.00036	0.0002
2003	0.00038	0.00038	0.00038	0.0002
2004	0.00039	0.00039	0.00039	0.0002
2005	0.00041	0.00041	0.00041	0.0002
2006	0.00042	0.00042	0.00042	0.0002
2007	0.00045	0.00045	0.00045	0.0002
2008	0.00046	0.00046	0.00046	0.0002
2009	0.00050	0.00050	0.00050	0.0002

2010		0.00053		0.00053		0.00053		0.0003	
2011		0.00055		0.00055		0.00055		0.0003	
2012		0.00057		0.00057		0.00057		0.0003	
2013		0.00060		0.00060		0.00060		0.0003	
2014		0.00063		0.00063		0.00063		0.0003	
2015		0.00065		0.00065		0.00065		0.0003	
Year		HCB (kg)		PCB (kg)		PCDD/PCDF (g I-TEQ)			
1990		0.0011		0.00021		0.023			
1991		0.0012		0.00022		0.023			
1992		0.0012		0.00023		0.024			
1993		0.0013		0.00025		0.027			
1994		0.0014		0.00026		0.027			
1995		0.0015		0.00027		0.029			
1996		0.0016		0.00030		0.032			
1997		0.0016		0.00031		0.033			
1998		0.0018		0.00033		0.036			
1999		0.0019		0.00035		0.037			
2000		0.0020		0.00037		0.039			
2001		0.0020		0.00037		0.040			
2002		0.0022		0.00040		0.043			
2003		0.0022		0.00042		0.045			
2004		0.0023		0.00043		0.047			
2005		0.0024		0.00045		0.048			
2006		0.0025		0.00046		0.049			
2007		0.0027		0.00050		0.053			
2008		0.0027		0.00051		0.055			
2009		0.0029		0.00055		0.059			
2010		0.0032		0.00059		0.063			
2011		0.0032		0.00060		0.065			
2012		0.0034		0.00063		0.068			
2013		0.0036		0.00066		0.071			
2014		0.0037		0.00070		0.074			
2015		0.0038		0.00072		0.077			
Year		Benzo(a)pyrene (kg)		Benzo(b)fluoranthene		Benzo(k)fluoranthene (kg)		Indeno(1,2,3-cd) pyrene	
1990		0.10		0.05		0.05		0.05	
1991		0.10		0.06		0.05		0.05	
1992		0.11		0.06		0.05		0.06	
1993		0.12		0.06		0.06		0.06	
1994		0.12		0.07		0.06		0.06	
1995		0.13		0.07		0.06		0.07	
1996		0.14		0.08		0.07		0.08	
1997		0.14		0.08		0.07		0.08	
1998		0.16		0.09		0.08		0.08	
1999		0.16		0.09		0.08		0.09	
2000		0.17		0.09		0.08		0.09	
2001		0.18		0.10		0.09		0.09	
2002		0.19		0.10		0.09		0.10	
2003		0.20		0.11		0.10		0.10	
2004		0.20		0.11		0.10		0.11	
2005		0.21		0.12		0.10		0.11	
2006		0.22		0.12		0.11		0.12	
2007		0.23		0.13		0.11		0.12	
2008		0.24		0.13		0.12		0.13	
2009		0.26		0.14		0.13		0.14	
2010		0.28		0.15		0.14		0.15	
2011		0.28		0.16		0.14		0.15	
2012		0.30		0.16		0.15		0.16	
2013		0.31		0.17		0.15		0.17	
2014		0.33		0.18		0.16		0.17	
2015		0.34		0.18		0.17		0.18	
Year	Hg (kg)	Pb (kg)	Cd (kg)	As (kg)	Cr (kg)	Cu (kg)	Ni (kg)	Se (kg)	Zn (kg)
1990	22522	228	38	104	103	95	132	151	1218
1991	22903	233	39	106	105	97	135	154	1243
1992	23957	244	41	111	110	101	141	161	1300
1993	26509	270	45	122	122	112	156	178	1439
1994	26848	275	46	125	124	114	159	181	1467
1995	28051	294	49	133	133	121	169	193	1565
1996	29980	325	54	147	147	135	188	214	1733
1997	28870	330	55	149	149	136	190	217	1758

1998	27928	355	60	161	160	147	205	234	1895
1999	25057	374	63	170	169	155	216	247	1996
2000	21981	393	66	178	177	163	227	259	2095
2001	13659	402	67	182	182	166	232	265	2144
2002	14354	431	72	195	195	178	249	284	2298
2003	14699	446	75	202	201	185	257	294	2377
2004	14422	466	78	211	210	193	269	307	2483
2005	14014	484	81	219	218	200	279	319	2579
2006	12509	494	83	224	223	205	285	326	2635
2007	13169	534	90	242	241	221	308	352	2849
2008	12921	547	92	248	247	226	315	360	2914
2009	14084	587	98	266	265	243	339	387	3132
2010	14958	633	106	287	286	262	365	417	3373
2011	14001	647	108	293	292	268	373	426	3449
2012	13362	680	114	308	307	282	392	448	3626
2013	13984	712	119	323	321	295	411	469	3795
2014	14645	745	125	338	337	309	430	491	3974
2015	15122	770	129	349	348	319	444	507	4104

8.9.3 Uncertainty and time series' consistency

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

8.9.4 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.

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

In 2017 submission emission factors from Guidebook 2016 were taken in use for whole time series.

8.9.6 Source-specific planned improvements

None.

8.10 Wastewater Handling (NFR 5D)

Changes in chapter	
Update of emission figures	March 2017JMP
Update of text	April 2017 KS. JMP
Change in methodology	none
Other (e.g. language. layout)	April 2017 KS

8.10.1 Source category description

The emission sources cover municipal (domestic) and industrial wastewater handling plants 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	
Update of emission figures	March 2017 JMP
Update of text	April 2017 KS & JMP
Change in methodology	none
Other (e.g. language. layout)	April 2017 KS

8.10.1 Source category description

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 2015.

Pollutant	Emissions from domestic wastewater handling in 2015	Total emissions in 2015	Unit	Share of total emissions %	% reported by the plants
NH3	<0.001	31.85	Gg	<0.1	100
NMVOC	0.141	87.76	Gg	0.2	4.4

The NMVOC emissions calculated for the inventories under the UNECE CLRTAP and the EU NECD are also reported under the UNFCCC reporting and the activity data used in the calculation are the same as used in estimation of greenhouse gases from this sector.

8.10.2 Methodological issues

NMVOC emissions

The calculation of NMVOC emissions from municipal (NFR 5 D 1) and industrial (NFR 5 D 2) wastewater treatment is based on wastewater flow data and an emission factor derived from the concentration of NMVOCs in the effluents. According to a national study (Myllyperkiö, 2005), NMVOC emissions from municipal wastewater treatment were 0.12 Gg in 1990. For the other years, NMVOC concentration in biogas (and methane emissions) and volumes for municipal and industrial wastewaters available in VAHTI have been used in the calculation. The wastewater handling volumes are presented in Table 6.22.

Table 6.22. BOD_5 and COD loads in 1990-2015 (1 000 t).

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Domestic wastewater											
Collected COD_7 load	117	-	-	-	-	114	-	-	-	-	119
Collected BOD_5 load	100	101	92	93	94	97	94	96	96	101	101
Uncollected BOD_5 load	24	22	22	23	22	22	22	22	20	19	20
Industrial wastewater											
COD load	852	749	736	769	814	843	784	770	778	795	795
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Domestic wastewater											
Collected COD_7 load	-	-	-	-	132	126	134	134	129	129	133
Collected BOD_5 load	101	101	109	107	113	108	114	114	110	111	114
Uncollected BOD_5 load	19	19	19	18	18	18	18	18	18	18	18
Industrial wastewater											
COD load	755	932	904	895	895	1022	1027	929	709	764	814
	2012	2013	2014	2015							
Domestic wastewater											
Collected COD_7 load	134	130	132	134							
Collected BOD_5 load	114	111	113	115							
Uncollected BOD_5 load	18	18	18	17							
Industrial wastewater											
COD load	809	781	770	825							

NMVOC emissions from septic tanks are calculated according to the method used for landfills (biogas concentration 485 mg/m^3).

The number of population without domestic wastewater collection and handling systems is presented in Table 6.23(a) and 6.23(b)

Table 6.23. (a) Population (1000 persons) having uncollected wastewater handling system.

Year	Population (1000 persons)	Year	Population (1000 persons)	Year	Population (1000 persons)
1990	1 092	2000	915	2010	824
1991	1 013	2001	877	2011	828
1992	1 023	2002	868	2012	819
1993	1 041	2003	847	2013	810
1994	1 003	2004	833	2014	802
1995	1 023	2005	830	2015	793
1996	999	2006	812		
1997	983	2007	803		
1998	950	2008	806		
1999	907	2009	814		

- *Table 6.23 (b) Population (1,000 persons) having collected or uncollected wastewater treatment system and dry closets and protein consumption (g/person/day) (Finland's NIR Table 7.5-5)*

	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Uncollected wastewater	1 092	1 023	915	830	812	803	806	814	824	828	819	810	802	793
Collected wastewater	3 706	3 903	4 170	4 333	4 373	4 406	4 427	4 444	4 457	4 477	4 513	4 546	4 579	4 607
Dry closet	100	102	91	83	81	80	81	81	82	83	82	81	80	79
Protein consumption (g/person/day)	100	97	100	104	105	107	107	107	108	109	110	111	113	114

-

NH3, Sox and NOx emissions

Emissions from waste incineration are reported by the plants according to the monitoring requirements in the environmental permits. Fuel based emissions are reported in energy sector.

Altogether there were 4 wastewater treatment plants in 2014 which were obligated to report their emission to government authorities. In Finland there is approximately 540 wastewater treatment plants, each of them treat wastewater from more than 50 people (Finnish Water Utilities Association, FIWA), 2016). However, the allocation of emissions has changed over the years.

HCB emissions

HCB emissions from 2007-2011 are based on measurement data reported by the plants.
Further studies will be made to check if the emissions should be calculated for the other years, too.

8.10.3 Uncertainty and time series' consistency

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

8.10.4 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.

8.10.5 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 were since the 2016 submission reported under NFRs 5D1 and 5D2.

8.10.6 Source-specific planned improvements

Planned for the 2018 submission

HCB emissions from 2007-2011 are based on measurement data reported by the plants.
Further studies will be made to check if HCB emissions should be calculated for other years than 2007-2011.

Industrial wastewater handling (NFR 5D2)

Changes in chapter	
Update of emission figures	March 2017 JMP
Update of text	April 2017 KS & JMP
Change in methodology	none
Other (e.g. language. layout)	April 2017 KS

8.10.7 Source category description

The shares of emissions for each air pollutant reported under the NFR category are presented in Table 6.24Table 6.21.

Table 6.24. Contribution of Industrial wastewater handling (NFR 5D2) to total emissions in 2015.

Pollutant	Emissions from industrial wastewater handling in 2015	Total emissions in 2015	Unit	Share of total emissions %	% reported by the plants
NMVOC	0.156	87.76	Gg	0.2	0

The NMVOC emissions calculated for the inventories under the UNECE CLRTAP and the EU NECD are also reported under the UNFCCC reporting and the activity data used in the calculation are the same as used in estimation of greenhouse gases from this sector.

8.10.8. Methodological issues

NMVOC emissions
The calculation of NMVOC emissions from municipal (NFR 5 D 1) and industrial (NFR 5 D 2) wastewater treatment is based on wastewater flow data and an emission factor derived from the concentration of NMVOCs in the effluents. According toa national study (Myllyperkiö, 2005) NMVOC emissions from municipal wastewater treatment were 0.12 Gg in 1990. For the other years, NMVOC concentration in biogas (and methane emissions) and volumes for municipal and industrial wastewaters available in VAHTI have been used in the calculation. The wastewater handling volumes are presented in Table 6.22.

8.10.9. Uncertainty and time series' consistency

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

8.10.10 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.

8.10.11 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 were since the 2016 submission reported under NFRs 5D1 and 5D2.

8.10.12 Source-specific planned improvements

None.

8.11 Other Wastewater handling (NFR 5D3)

8.11.1 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.

8.11.1 Source-specific planned improvements

The change of the notation key into NO will be studied for the next submission.

8.11 Other waste (NFR 5E)

Changes in chapter	
Update of emission figures	March 2017 JMP
Update of text	April 2017 KS & JMP
Change in methodology	none
Other (e.g. language. layout)	April 2017 KS

8.11.1 Source category description

NFR 5 E Other covers emissions from
- house and car fires (particles, PCDD/F and heavy metals)
- landfill fires (PCDD/F and PCBs)
- latrines (NH3)

The shares of emissions for each air pollutant reported under the NFR category are presented in Table 6.25Table 6.24Table 6.21.

Table 6.25. Contribution of Other waste (NFR 5E) to total emissions in 2015.

Pollutant	Emissions from other waste in 2015	Total emissions in 2015	Unit	Share of total emissions %	% reported by the plants
As	<0.001	2.43	Mg	<0.1	0
BC	0.009	4.60	Gg	0.2	0
Cd	<0.001	0.92	Mg	<0.1	0
Cr	<0.001	15.63	Mg	<0.1	0
Cu	0.002	39.57	Mg	<0.1	0
Hg	<0.001	0.64	Mg	<0.1	0
NH3	0.375	31.85	Gg	1.2	0
Pb	<0.001	13.93	Mg	<0.1	0
TSP	0.102	50.02	Gg	0.2	0
PCBs	53.582	151.89	kg	35.3	0
PCDD/ Fs	1.078	14.25	g I-Teq	7.6	0
PM10	0.102	32.15	Gg	0.3	0
PM2.5	0.102	21.98	Gg	0.5	0

8.11.2 Methodological issues

Car and house fires

Particles

Emissions from house and car fires are calculated using emission factors: from the Guidebook 2016 as follows; car fires 2.3 kg/fire (TSP PM10,PM2.5), house fires (detached houses) 143.82 kg /fire (TSP, PM10, PM2.5), house fires (undetached houses) 61.62 kg/fire (TSP, PM10, PM2.5), house fires (apartment buildings) 43.78 kg/fire (TSP, PM10, PM2.5) and house fires (industrial buildings) 27.23 kg/fire

(TSP, PM10, PM2.5). In 2016 submission the whole time series has been recalculated as result from correct 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 EF:s 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).

Heavy metals
Emission factors for heavy metals are presented in 0.

Table 6.26. Emission factors for heavy metals from house fires.

Pollutant	Unit	Emission factors for house fires (Guidebook 2016)			
		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	27.24
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
Emission factors from car and house fires are as follows: car fires 0.047 ug I-TEQ/fires, for house fires 1.43817 ug I-TEQ/fires (detached houses), 0.61621 ug I-TEQ/fires (undetached houses), 0.43779 ug I-TEQ/fires (apartment buildings) and 0.27234 ug I-TEQ/fires (industrial buldings). All factors are from Guidebook 2016.

Activity data
Activity data for 1990-2015 is presented in Table 6.27. For house fires it is assumed based on information from Rescue Services that 26% of house fires are undetached house fires, 4% detached house fires, 10% apartment building fires and 18% industrial building fires[1]. From vehicle fires 68% is passenger car fires (Rescue Services, 2002). Fire Statistics were changed in 2009 resulting lower amount of house fires compared to previous years.

Table 6.27. Activity data: car and house fires (Rescue Services, 2016)

Year	**Car fires** (Rescue Services)	**House fires** (Rescue Services)	**Year**	**Car fires** (Rescue Services)	**House fires** (Rescue Services)
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			
2001	1768 car fires	3 040 house fires			
2002	1836 car fires	3 040 house fires			
2003	1836 car fires	3 040 house fires			
2004	1809 car fires	3 420 house fires			
2005	1788 car fires	3 670 house fires			

Landfill fires

PCDD/F and PCB

Emissions from unintentional landfill fires were calculated for the first time in 2009 submission with information of the volume of waste burned in the landfills (expert estimate. SYKE. 2007). At present unintentional landfill fires are quite uncommon and the activity data presented in 0 needs to be re-evaluated.

Table 6.28. Estimation of annual amount of waste burned in unintentional landfill fires (t)

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
84 000	84 000	84 000	78 011	75 093	72 022	66 801	61 426	56 205	50 216
2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
46 069	42 384	37 316	38 084	28 256	26 874	26 874	23 035	19 196	18 888
2010	2011	2012	2013	2014	2015				
18 735	18 735	18 735	18 735	18 735	18735				

For calculation of PCDD/F emissions, the emission factor 1 μg I-TEQ was taken from the UNEP Standardized Toolkit (2005). PCB emissions were calculated using the emission factor 2.86 g/t (EMEP/CORINAIR Guidebook, September 2005), the used EF is actually a factor for open burning of waste.

Latrines

NH_3

In 2013 submission also NH_3 emissions from latrines were included to the inventory for first time. In 2016 submissions emissions were reallocated to the NFR 5E from NFR 2G for years 2014 emissions. In 2017 submission the whole time series is reported under NFR 5E.

Emission are calculated according to Guidebook 2016 by the emission factor of 1.6 kg/person/year and activity data from Statistics Finland (the amount of summer cottages in Finland 1970-2016). It is assumed that a summer cottage (where in Finland latrines are mainly in use) is in use only during summer months (4 month per year). It is also assumed that in 70 % of summer cottages a latrine is in use, and approximately 2 persons uses it. According Statistics Finland in 1990 were 367 686 summer cottages, in 1995 416 236, in 2000 450 569, in 2005 472 277 and in 2012 496 208. After 2012 the statistics are updated annually, in 2013 the number of summer cottages were 496 209, in 2014 500 400 and in 2015 501 600 (Statistics Finland, 2016)

Calculated emissions (particles (TSP, PM10, PM2.5, BC) heavy metals (Pb, Cd, As, Cr, Cu, Ni, Se, Hg and Zn) and POP compounds (HCB, PCB, dioxins and PAH compounds)) from other waste are presented in Table 6.29

Table 6.29. Calculated emissions (particles, heavy metals and POP compounds) in other waste (NFR 5E)

Year	TSP (Gg)	PM10 (Gg)	PM2.5 (Gg)	PCDD/PCDF (g I-TEQ)
1990	0.30	0.30	0.30	3.03
1991	0.30	0.30	0.30	3.05
1992	0.29	0.29	0.29	2.97
1993	0.20	0.20	0.20	2.01
1994	0.15	0.15	0.15	1.53
1995	0.17	0.17	0.17	1.78
1996	0.18	0.18	0.18	1.81
1997	0.16	0.16	0.16	1.55
1998	0.16	0.16	0.16	1.55
1999	0.15	0.15	0.15	1.50
2000	0.16	0.16	0.16	1.56
2001	0.17	0.17	0.17	1.58
2002	0.17	0.17	0.17	1.58
2003	0.15	0.15	0.15	1.58
2004	0.17	0.17	0.17	1.77
2005	0.18	0.18	0.18	1.89
2006	0.20	0.20	0.20	2.05
2007	0.20	0.20	0.20	2.06
2008	0.22	0.22	0.22	2.28
2009	0.14	0.14	0.14	1.42
2010	0.14	0.14	0.14	1.45

2011	0.13	0.13	0.13	1.33
2012	0.12	0.12	0.12	1.26
2013	0.12	0.12	0.12	1.23
2014	0.11	0.11	0.11	1.12
2015	0.10	0.10	0.10	1.06

Year	As (kg)	Cd (kg)	Cu (kg)	Cr (kg)	Pb (kg)	Hg (kg)
1990	2.77	1.74	6.14	2.64	0.86	1.74
1991	2.78	1.76	6.18	2.66	0.87	1.76
1992	2.72	1.71	6.03	2.59	0.85	1.71
1993	1.84	1.16	4.09	1.76	0.58	1.16
1994	1.39	0.88	3.09	1.33	0.43	0.88
1995	1.61	1.02	3.58	1.54	0.50	1.02
1996	1.62	1.02	3.59	1.55	0.51	1.02
1997	1.51	0.95	3.34	1.44	0.47	0.95
1998	1.48	0.94	3.29	1.42	0.46	0.94
1999	1.34	0.85	2.98	1.28	0.42	0.85
2000	1.44	0.91	3.20	1.38	0.45	0.91
2001	1.60	1.01	3.54	1.52	0.50	1.01
2002	1.58	1.00	3.52	1.51	0.49	1.00
2003	1.39	0.87	3.08	1.32	0.43	0.87
2004	1.57	0.99	3.50	1.50	0.49	0.99
2005	1.69	1.07	3.75	1.61	0.53	1.07
2006	1.84	1.16	4.09	1.76	0.57	1.16
2007	1.85	1.17	4.11	1.77	0.58	1.17
2008	2.06	1.30	4.58	1.97	0.64	1.30
2009	1.26	0.79	2.80	1.20	0.39	0.79
2010	1.28	0.81	2.85	1.22	0.40	0.81
2011	1.17	0.74	2.60	1.12	0.37	0.74
2012	1.11	0.70	2.47	1.06	0.35	0.70
2013	1.08	0.68	2.39	1.03	0.34	0.68
2014	0.99	0.62	2.19	0.94	0.31	0.62
2015	0.93	0.58	2.05	0.88	0.29	0.58

8.11.3 Uncertainty and time series' consistency

The results of the uncertainty analysis are presented in Parat 3 of the IIR.

8.11.4 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.

8.11.5 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.
- 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
- NH3 emissions from latrines was reallocated to 5E, however, the change is done at the moment only for years 2014 and 2015 emissions.
- Heavy metal emissions from NFR 5E (house and car fires) were updated according Guidebook 2016. Source-specific planned improvements

8.11.6 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.