3.B - Manure Management

Short description

NFR-Code	Name of Category	Method	AD	EF	Key Category [1]	State of reporting
3.B	Manure Management	see sub-category details				
consisting of / including source categories						
3.B.1.a & 3.B.1.b	Cattle	T3 (NH_3), T2 (NO_x, TSP, PM_{10}, $PM_{2.5}$, NMVOC)	NS, RS	CS (NH_3, NO_x), D (TSP, PM_{10}, $PM_{2.5}$, NMVOC)	L & T: NH_3 (for 3.B.1.b), NMVOC	L: NH_3 (for 3.B.1.a)
3.B.2, 3.B.4.d, 3.B.4.e	Sheep, Goats, Horses	T2 (NH_3, NO_x, TSP, PM_{10}, $PM_{2.5}$), T1 (NMVOC)	NS, RS	CS (NH_3, NO_x), D (TSP, PM_{10}, $PM_{2.5}$, NMVOC)	no key category	
3.B.3	Swine	T3 (NH_3), T2 (NO_x, TSP, PM_{10}, $PM_{2.5}$), T1 (NMVOC)	NS, RS	CS (NH_3, NO_x), D (TSP, PM_{10}, $PM_{2.5}$, NMVOC)	L & T: NH_3, TSP	
3.B.4.a	Buffalo					NO, from 1990 until 1995, since 1996 IE, considered in 3.B.1.b
3.B.4.f	Mules and asses					IE, considered in 3.B.4.e
3.B.4.g i-iv	Poultry	T2 (NH_3, NO_x, TSP, PM_{10}, $PM_{2.5}$), T1 (NMVOC)	NS, RS	CS (NH_3, NO_x), D (TSP, PM_{10}, $PM_{2.5}$, NMVOC)	L: TSP (for 3.B.4.g i)	T: NH_3 (for 3.B.4.g iii)
3.B.4.h	Other animals					NE

Legend T = key source by Trend / L = key source by Level

Methods D: Default RA: Reference Approach T1: Tier 1 / Simple Methodology * T2: Tier 2* T3: Tier 3 / Detailed Methodology * C: CORINAIR CS: Country Specific M: Model as described in the EMEP/CORINAIR Emission Inventory Guidebook - 2019, in the group specific chapters.

AD:- Data Source for Activity Data NS: National Statistics RS: Regional Statistics IS: International

Statistics PS: Plant Specific data AS: Associations, business organisations Q: specific questionnaires, surveys

EF - Emission Factors D: Default (EMEP Guidebook) C: Confidential CS: Country Specific PS: Plant Specific data

Country specifics

must be updated

In 2019, NH_3 emissions from category 3.B (manure management) derived up to xx44.0 % from total agricultural emissions, which is equal to ~ xx267.0 kt NH_3. Within those emissions 51.7 % originate from cattle manure (~ 138.0 kt), 33.9 % from pig manure (ca. 90.6 kt), and 11.6 % from poultry manure (~ 30.9 kt). Calculations take into account the impact of anaerobic digestion of manure on the emissions.

NO_x emissions from category 3.B (manure management) contribute only 1.3 % (~ 1.5 kt) to the total agricultural NO_x emissions. They are calculated proportionally to N_2O emissions. (see Haenel et al., 2020, Chapter 3.3.4.3.5 [1]).

NMVOC emissions from category 3.B (manure management) contributed 97.6 % (316.5 kt) from total agricultural NMVOC emissions (324.3 kt).

In 2019, manure management contributed, respectively, xx71.4 % (xx43.6 kt), xx43.0 % (xx13.2 kt) and xx5.0 % (xx3.8 kt) to the total agricultural TSP, PM_{10} and $PM_{2.5}$ emissions (TSP: 61.1 kt, PM_{10}: 30.6 kt, $PM_{2.5}$: 4.5 kt, respectively).

Activity data for all pollutants

The Federal Statistical Agency and the Statistical Agencies of the federal states carry out surveys in

order to collect, along with other data, the head counts of animals. The results of these surveys are used for emission calculations, for details see Haenel et al., 2020, Chapter 3.4.2 [1].

The animal population figures used in the inventory are presented in Table 1. Buffaloes are included in the cattle population figures, mules and asses are included in the horse population figures (IE), see Haenel et al., (2020), Chapters 4.1 and 7.1 [1]. In the first years after the German reunification in 1990 animal livestock decreased markedly. The head counts for cattle continued to decrease significantly until 2006/2007, followed by a more or less stable period until 2014. Since 2015 a slight decrease occurred. In 2018, dairy cattle numbers are xx64.5 % of 1990 numbers, while the total population of other cattle is at xx59.8 % of 1990. Swine numbers decreased until 1995 and then increased slightly. Since 2014 a slight decrease occurred (xx2019: xx83.1 % of 1990). The 2019 numbers of horses, sheep and goats are, respectively, at xx85.9 %, xx56.5 % and xx160.6 % of 1990.

Figures for broilers and turkeys are showing a massive increase since 1990. In total, 2019 poultry population figures are at xx153.8 % of 1990. A detailed description of the animal figures used can be found in the National Inventory Report (NIR 2020 [11], Chapter 5.1.3.2.3).

Table 1: Population of animals

Population of animals (in 1000)														
	1990	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
dairy cattle	6,354.6	5,229.4	4,569.8	4,236.4	4,183.1	4,190.1	4,190.5	4,267.6	4,295.7	4,284.6	4,217.7	4,199.0	4,100.9	4,011.7
other cattle	13,133.4	10,660.5	9,968.9	8,800.4	8,628.7	8,340.4	8,319.1	8,418.4	8,446.5	8,350.8	8,248.9	8,082.2	7,848.2	7,627.9
buffalo	NO	NO	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
mules and asses	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
horses	499.5	634.1	499.5	508.4	461.8	461.6	461.5	461.3	454.9	448.4	442.0	435.5	429.1	422.6
sheep	3,266.1	2,990.7	2,743.3	2,643.1	2,245.0	1,979.7	1,965.9	1,877.2	1,892.4	1,866.9	1,851.0	1,863.2	1,846.0	1,813.6
goats	90.0	100.0	140.0	170.0	149.9	143.4	136.8	130.2	133.1	135.9	138.8	141.7	144.6	147.4
swine	26,502.5	20,387.3	21,767.7	22,742.8	22,244.4	22,787.9	23,648.3	23,391.2	23,666.9	22,978.5	22,761.2	22,920.8	22,019.2	21,596.4
laying hens	53,450.5	45,317.3	44,225.6	38,203.6	35,279.0	39,514.9	43,750.8	47,986.7	49,303.0	50,619.3	51,935.5	52,524.4	53,561.4	53,901.4
broilers	35,393.0	42,025.8	50,359.9	56,762.5	67,531.1	77,402.6	87,274.1	97,145.6	96,027.5	94,909.4	93,791.3	93,791.3	93,791.3	93,791.3
turkeys	5,029.2	6,742.0	8,893.1	10,611.1	11,344.0	11,981.2	12,618.5	13,255.7	12,957.1	12,658.5	12,359.9	12,359.9	12,359.9	12,359.9
pullets	17,210.8	14,592.0	14,240.5	12,301.4	11,303.3	12,749.3	14,195.2	15,641.2	14,734.7	13,828.3	12,921.8	12,921.8	12,921.8	12,921.8
ducks	2,013.7	1,933.7	2,055.7	2,352.2	3,164.3	3,029.5	2,894.6	2,759.7	2,585.3	2,410.8	2,236.4	2,236.4	2,236.4	2,236.4
geese	781.5	617.0	404.8	329.5	278.1	366.8	455.5	544.2	472.5	400.8	329.0	329.0	329.0	329.0
other animals: no data available a)														

a) Animal numbers of other animals are not available. Emissions of other animals were approximated with estimated population figures for a single year (see Rösemann et. al., 2017, Chapter 9) [12] and submitted to the TERT oft he NECD-Review. The TERT confirmed that emissions are below the threshold of significance. For GHG emission reporting the UNFCCC has acknowledged that the emissions from Germany's other animals are negligible. To ensure consistency between UNFCCC and UNECE/NEC reporting, no air pollutants from other animals are reported.

Additional data

Emission calculations in accordance with a Tier 2 or Tier 3 method require data on animal performance (animal weight, weight gain, milk yield, milk protein content, milk fat content, numbers of births, numbers of eggs and weights of eggs) and on the relevant feeding details (phase feeding, feed components, protein and energy content, digestibility and feed efficiency). To subdivide officially

recorded total numbers of turkeys into roosters and hens, the respective population percentages need to be known. Details on data requirements for the modelling of emissions from livestock husbandry in the German inventory can be found in Haenel et al. (2020), Chapters 4 to 8 [1].

Most of the data mentioned above is not available from official statistics and was obtained from literature, from publications by agricultural association, from regulations for agricultural consulting in Germany and from expert judgments. For 1991, 1995 and 1999, frequency distributions of feeding strategies, husbandry systems (shares of pasturing/stabling; shares of various housing methods), storage types as well as techniques of farm manure spreading were obtained with the help of the RAUMIS agricultural sector model (Regionalisiertes Agrar- und UmweltInformationsystem für Deutschland/ Regionalised agricultural and environmental information system for Germany). RAUMIS has been developed and is operated by the Institute of Rural Studies of the Thünen Institute (Federal Research Institute for Rural Areas, Forestry and Fisheries). For an introduction to RAUMIS see Weingarten (1995) [6]; a detailed description is provided in Henrichsmeyer et al. (1996) [7].

RAUMIS did not model complete time series but only selected years. RAUMIS data for the years 1991, 1995, and 1999 are used in the inventory for years 1990 – 1993, 1994 – 1997, and 1998 – 1999, respectively. For the year 2010, respective data are used that were derived from the 2010 official agricultural census and the simultaneous survey of agricultural production methods (Landwirtschaftliche Zählung 2010, Statistisches Bundesamt/ Federal Statistical Office) as well as the 2011 survey on manure application practices (Erhebung über Wirtschaftsdüngerausbringung, Statistisches Bundesamt/ Federal Statistical Office).

For the year 2015, data on techniques of farm manure spreading from the 2016 official agricultural census (Agrarstrukturerhebung 2016, Statistisches Bundesamt / Federal Statistical Office) are used. The gaps between the latest RAUMIS model data (1999) and the first official data (2010) were closed by linear interpolation on district level. For 2011 to 2018 the 2010 data was kept, with the exception of data on techniques of farm manure spreading. For the latter the data was linearly interpolated between 2010 and 2015, and for 2016 to 2018 the 2015 data was kept. In addition it was taken into account that, as of 2012, slurry spread on bare soil has to be incorporated within four hours. For a description of the RAUMIS data, the data from official surveys and additional data from other sources see Haenel et al. (2020), Chapter 3.4 [1]. Time series of frequency distributions of housing systems, storage systems and application techniques as well as the corresponding emission factors are provided in NIR 2020 [11],Chapter 19.3.2.

NH3 and NOx

must be updated

Methodology

N in manure management N excretion

In order to determine NH_3 and NO_x emissions from manure management of a specific animal category, the individual N excretion rate must be known as well as, for NH_3, the TAN content of the N excretions. Default excretion rates are provided by IPCC Guidelines and default TAN contents can be found in the EMEP Guidebook (EMEP, 2016) [10]. However, the German agricultural emission inventory uses N mass balances to calculate the N excretions and the TAN contents of almost all

animal categories to be reported. N mass balance calculations (see below) consider N intake with feed, N retention due to growth, N contained in milk and eggs, and N in offspring. Table 2 presents national means of N excretions and TAN contents. For methodological details and mass balance input data see Haenel et al. (2020), Chapter 3.3.4.3 as well as Chapters 4 to 8 [1].

*Table 2: National means of N excretions and TAN contents*

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
mean N excretions in kg per animal place													
dairy cattle	92.0	97.9	103.8	108.9	110.3	111.0	111.3	110.7	111.8	113.1	114.5	114.3	116.8	120.0
other cattle	38.1	40.4	41.9	41.8	42.6	42.4	42.4	42.5	42.5	42.8	42.7	42.9	43.1	43.5
horses	48.2	48.1	49.0	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8	48.8
sheep	7.7	7.7	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
goats	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0
swine	12.1	12.6	12.7	12.8	12.9	12.9	12.9	13.0	13.0	13.0	13.1	13.2	13.3	13.3
laying hens	0.82	0.79	0.78	0.80	0.87	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.89	0.89
broilers	0.48	0.44	0.49	0.52	0.57	0.54	0.49	0.45	0.48	0.50	0.50	0.51	0.52	0.51
turkeys	2.0	2.0	2.0	2.2	2.2	2.2	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
pullets	0.33	0.29	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
ducks	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61	0.61
geese	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
mean TAN contents in %													
dairy cattle	58.0	55.0	52.9	51.3	49.9	49.6	49.3	49.2	48.7	48.6	48.3	48.2	47.6	47.2
other cattle	65.0	64.7	64.5	64.5	64.8	64.8	64.9	64.9	65.0	65.0	64.9	64.9	64.9	64.9
horses	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
sheep	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
goats	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
swine	74.3	74.1	73.8	73.7	73.3	73.2	73.0	73.0	72.9	72.9	72.8	72.7	72.7	72.7
laying hens	70.3	69.6	69.1	69.4	70.0	70.0	70.0	70.1	70.2	70.1	70.1	70.1	70.1	70.1
broilers	60.8	60.1	58.0	55.1	52.8	52.8	52.8	52.8	52.8	52.8	52.8	52.8	52.8	52.8
turkeys	63.9	63.9	62.2	63.0	62.1	62.3	62.9	62.6	62.6	62.6	62.6	62.6	62.6	62.6
pullets	67.8	67.8	67.8	67.8	67.8	67.8	67.8	67.8	67.8	67.8	67.8	67.8	67.8	67.8
ducks	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9
geese	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0

N mass flow and emission assessment

The calculation of the emissions of NH_3, N_2O, NO_x and N2 from German animal husbandry is based on the so-called N mass flow approach (e. g. Dämmgen and Hutchings, 2008, [3]). This approach differentiates between N excreted with faeces (organic nitrogen Norg, i. e. undigested feed N) and urine (total ammoniacal nitrogen TAN, i. e. fraction of feed N metabolized). The N flow within the manure management system is treated as depicted in the figure below. This method reconciles the requirements of both the Atmospheric Emission Inventory Guidebook for NH_3 emissions (EMEP, 2016) [10], and the IPCC guidelines for greenhouse gas emissions (IPCC (2006) [4])). Reidy et al. (2008),[2])), showed for several European countries (Germany, the Netherlands, Switzerland, United Kingdom) that their N-flow based inventory models yielded, in spite of national peculiarities, comparable results as long as standardised data sets for the input variables were used.

Not explicitly shown in the N mass flow scheme is air scrubbing in housing and anaerobic digestion of

manure. These issues are separately described farther below. Note that emissions from grazing and application are reported in sector 3.D.
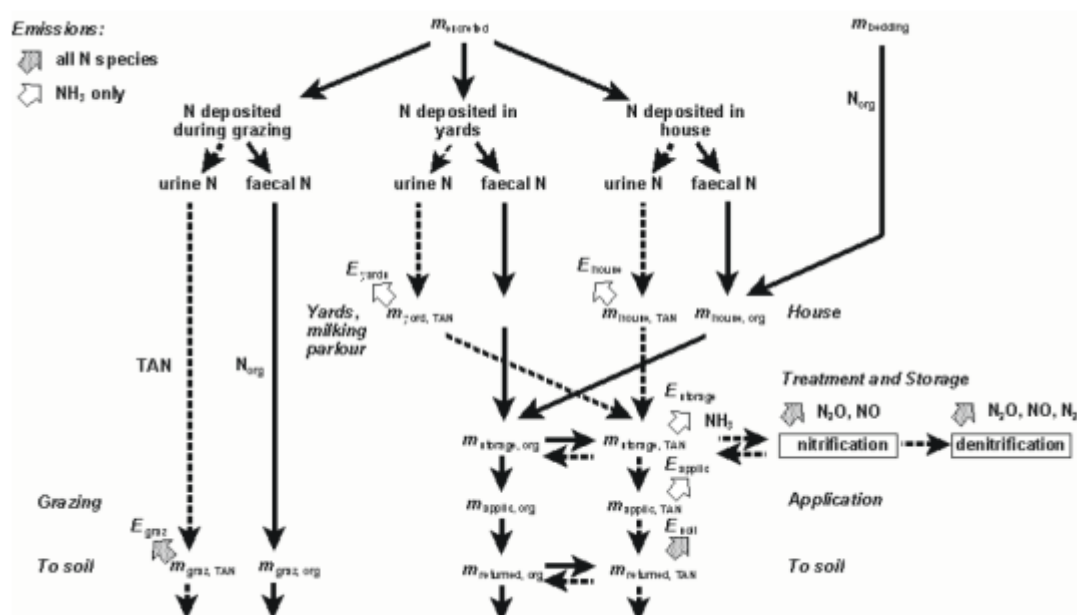
General scheme of N flows in animal husbandry

m: mass from which emissions may occur. Narrow broken arrows: TAN (total ammoniacal nitrogen); narrow continuous arrows: organic N. The horizontal arrows denote the process of immobilisation in systems with bedding occurring in the house, and the process of mineralisation during storage, which occurs in any case. Broad arrows denote N-emissions assigned to manure management (Eyard NH3 emissions from yards; Ehouse NH3 emissions from house; Estorage NH_3, N_2O, NO_x and N2 emissions from storage; Eapplic NH_3 emissions during and after spreading; Egraz NH_3, N_2O, NO_x and N2 emissions during and after grazing; Esoil N_2O, NO_x and N2 emissions from soil resulting from manure input).

The figure allows tracing of the pathways of the two N fractions after excretion. The various locations where excretion may take place are considered. The partial mass flows down to the input to soil are depicted. During storage Norg can be transformed into TAN and vice versa. Both, the way and the amount of such transformations may be influenced by manure treatment processes like, e. g., anaerobic digestion where a considerable fraction of Norg is mineralized to TAN. For details see Haenel et al. (2020), Chapters 3.3.4.3 and 3.3.4.4 [1]. Wherever NH_3 is emitted, its formation is related to the amount of the TAN present. For poultry the excretion of uric acid nitrogen (UAN) should be used instead of TAN (see Dämmgen and Erisman, 2005, [5]). In line with EMEP (2016) [10], it is assumed that UAN excreted can be considered TAN. N_2O emissions are related to the total amount of N available (Norg + TAN). NO_x emissions (i. e. NO emissions) are calculated proportionally to the N_2O emissions, see section 'Emission factors'. Note that the N_2O, NO_x and N2 emissions from the various storage systems include the respective emissions from the related housing systems.

Air scrubber systems in swine and poultry housings

For pig and poultry production the inventory considers the effect of air scrubbing. Data on frequencies of air scrubbing facilities and the removal efficiency are provided by KTBL (Kuratorium für Technik und Bauwesen in der Landwirtschaft / Association for Technology and Structures in Agriculture). The average removal efficiency of NH_3 is xx80 % for swine and xx70 % for poultry, while for TSP and PM_{10}

the rates are set to xx90 % and for $PM_{2.5}$ to xx70 % for both animal categories. For swine, for the first time, two types of air scrubbers are distinguished: certified systems that remove both NH_3 and particles, and non-certified systems that remove only particles.

According to the KTBL data, xx6.6 % of all pig places were equipped with certified systems in 2019, another xx0.7 % were equipped with non-certified systems. For poultry xx0.2 % of all laying hen places and xx0.9 % of all broiler places were equipped with air scrubbers that remove both NH_3 and particles. The amounts of NH_3-N removed by air scrubbing are completely added to the pools of total N and TAN for landspreading. For details see Haenel et al. (2020), Chapter 3.3.4.3.3 [1]).

Anaerobic digestion of manure

According to IPCC (2006) [4], anaerobic digestion of manure is treated like a particular storage type that, however, comprises three sub-compartments (pre-storage, fermenter and storage of digestates). For details see Haenel et al. (2020), Chapters 3.3.4.4 and 3.4.4.2 [1]). The resulting digestates are considered as liquid. Two different types of digestates storage systems are considered: gastight storage and open tank. For the open tank formation of a natural crust because of the usual co-fermentation of energy crops is taken into account. Furthermore, the modelling of anaerobic digestion and spreading of the digestates takes into account that the amount of TAN in the digestates is higher than in untreated slurry and that the frequencies of spreading techniques differ from those for untreated slurry.

NH_3 and NO emissions occur from pre-storage of solid manure, from non-gastight storage of digestates and from landspreading of digestates (NH_3 emissions and NO emissions from landspreading of digested manure are reported in 3.Da.2.a). There are no such emissions from pre-storage of slurry, from the fermenter and from gastight storage of digestates. Note that NH_3 and NO emissions calculated with respect to the digestion of animal manures do not comprise the contributions by co-digested energy crops. The latter are dealt with separately in 3.D.a.2.c and 3.I.

Emission Factors

Application of the N mass flow approach requires detailed emission factors for NH_3, N_2O, NO_x and N2 describing the emissions from the various housing and storage systems.

The detailed NH_3 emission factors are, in general, related to the amount of TAN available at the various stages of the N flow chain. The emission factors for laying hens, broilers, pullets, ducks and turkeys are related to N. Most NH_3 emission factors are country specific but some are taken from EMEP (2016) [10]. No specific NH_3 emission factors are known for the application of digested manure. However, due to co-fermentation of energy crops, the viscosity of digested manure resembles that of untreated cattle slurry. Hence, the emission factors for untreated cattle slurry are adopted for the application of digested manure. For the detailed emission factors of livestock husbandry see Haenel et al. (2020), Chapters 4 to 8; for emission factors of digested manure see Haenel et al. (2020), Chapter 3.4.4.2.4 [1]. Table 3 provides, by animal category, the implied NH3 emission factors for manure management (housing and storage). The overall German NH3 IEF for manure application is reported in section 3.D.a.2.a.

The detailed emission factors for N_2O, NO_x and N2 relate to the amount of N available which is N excreted plus, in case of solid manure systems, N input with bedding material. The N_2O emission factors are taken from IPCC (2006) [4]. The emission factors for NO_x and N2 are approximated as being proportional to the N2O emission factors, i. e. the NO-N and N2 emission factors are, respectively, one-tenth and three times the value of the N2O-N emission factor, see Haenel et al. (2020), chapter 3.3.4.3.5 [1]. This proportionality is also applied to anaerobic digestion of manure,

where N_2O emissions occur from pre-storage of solid manure and non-gastight storage of digestates with the emission factors being those used for normal storage of solid manure and the storage of untreated slurry with natural crust provided by IPCC (2006) [4]. Note that the inventory model calculates NO rather than NOx. The conversion of NO emissions into NOx emissions is achieved by multiplying the NO emissions with the NO_x/ NO molar weight ratio of 46/30. This relationship also holds for NO and NO_x emission factors.

All NO_x emissions from the agricultural sector are excluded from emission accounting by adjustment as they are not considered in the NEC and Gothenburg commitments.

Table 3 shows the implied emission factors of NH_3 and NO_x for the various animal categories. These emission factors normalize emissions from an animal category as the ratio of the total emission to the respective number of animals.

Table 3: IEF for NH_3 & NO_x from manure management

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
IEF in kg NH3 per animal place														
dairy cattle	9.8	10.4	11.1	12.1	12.6	12.5	12.4	12.3	12.2	12.3	12.4	12.3	12.4	12.6
other cattle	7.0	7.4	7.7	8.2	8.4	8.4	8.3	8.3	8.3	8.4	8.4	8.4	8.4	8.5
horses	13.5	13.5	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7	13.7
sheep	0.83	0.82	0.84	0.83	0.84	0.83	0.83	0.83	0.83	0.83	0.83	0.83	0.82	0.83
goats	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62	1.62
swine	4.42	4.41	4.37	4.32	4.19	4.15	4.12	4.12	4.11	4.09	4.10	4.10	4.11	4.10
laying hens	0.214	0.203	0.203	0.200	0.142	0.144	0.144	0.145	0.145	0.145	0.146	0.146	0.147	0.147
broilers	0.143	0.131	0.141	0.144	0.148	0.140	0.126	0.116	0.122	0.126	0.128	0.130	0.133	0.131
turkeys	0.788	0.788	0.792	0.869	0.831	0.835	0.888	0.858	0.857	0.856	0.857	0.857	0.859	0.859
pullets	0.108	0.096	0.088	0.087	0.082	0.081	0.081	0.079	0.079	0.079	0.079	0.080	0.080	0.080
ducks	0.193	0.193	0.193	0.192	0.190	0.189	0.188	0.187	0.186	0.186	0.186	0.186	0.186	0.186
geese	0.301	0.301	0.301	0.300	0.298	0.298	0.298	0.297	0.297	0.297	0.297	0.297	0.297	0.297
IEF in kg NOx per animal place														
dairy cattle	0.106	0.114	0.125	0.130	0.125	0.122	0.118	0.115	0.115	0.116	0.117	0.117	0.119	0.122
other cattle	0.053	0.058	0.060	0.064	0.065	0.064	0.064	0.063	0.063	0.063	0.063	0.063	0.063	0.064
horses	0.084	0.084	0.086	0.086	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.086	0.086	0.086
sheep	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
goats	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013
swine	0.010	0.012	0.012	0.014	0.016	0.016	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
laying hens	0.00027	0.00026	0.00026	0.00029	0.00035	0.00035	0.00034	0.00034	0.00033	0.00034	0.00034	0.00033	0.00033	0.00033
broilers	0.00016	0.00015	0.00016	0.00019	0.00022	0.00021	0.00018	0.00017	0.00018	0.00019	0.00019	0.00019	0.00019	0.00019
turkeys	0.00067	0.00067	0.00070	0.00083	0.00090	0.00090	0.00091	0.00089	0.00089	0.00089	0.00088	0.00088	0.00087	0.00087
pullets	0.00011	0.00010	0.00009	0.00010	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011	0.00011
ducks	0.00024	0.00024	0.00024	0.00025	0.00027	0.00027	0.00026	0.00027	0.00026	0.00027	0.00027	0.00026	0.00026	0.00026
geese	0.00018	0.00018	0.00019	0.00021	0.00023	0.00023	0.00021	0.00022	0.00021	0.00022	0.00022	0.00021	0.00021	0.00021

Trend discussion for Key Sources

Dairy cattle, other cattle and swine are key sources of NH_3 emissions from manure management. The time series of the total NH_3 emissions from all three categories are predominantly driven by the development of the animal numbers, see Table 1. This also holds for the negative trend of total emissions in the last few years. However, the effect of decreasing animal numbers is partly compensated by the continuously increasing animal performance. This leads to increasing N

excretions per animal, see Table 2, which, in principle, is reflected by increasing implied emission factors, see Table 3. For swine, as of 2012, the IEF is almost constant over time due to the use of air scrubbing systems that, to a high degree, remove NH_3 from the housings.

For NO_x there are no key categories.

Recalculations

All time series of the emission inventory have completely been recalculated since 1990. Tables REC-1 and REC-2 compare the recalculated time series for NH_3 and NO_x from 3B with the respective data of last year's submission. The overall recalculation effects are small. The biggest impact is from the update of the N excretions of suckler cows (recalculation No 4, see main page of the agricultural sector (https://iir-de-2020.wikidot.com/3-agriculture)) and pullets (No 10). Further details on recalculations are described in Haenel et al. (2020), Chapter 3.5.2. [1].

Tables REC-1 and REC-2: Comparison of the NH_3 and NO_x emissions of the submissions (SUB) 2020 and 2021

	SUB	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
NH3 emissions from manure management, in Gg															
Total	2021	303.26	256.08	256.91	257.32	252.88	253.17	257.21	258.42	260.03	256.36	253.73	252.85	247.20	243.31
	2020	325.60	275.30	276.21	276.48	271.11	271.43	275.70	277.31	279.59	276.30	273.98	272.83	267.01	
Dairy cattle	2021	62.19	54.13	50.81	51.28	52.71	52.44	51.86	52.30	52.48	52.72	52.10	51.64	50.74	50.40
	2020	75.05	65.57	61.87	62.48	64.19	64.22	63.79	64.44	65.29	65.88	65.43	64.96	64.24	
Other cattle	2021	91.39	78.88	76.79	71.73	72.48	69.75	69.39	70.26	70.48	69.85	68.90	67.62	65.85	64.47
	2020	101.28	87.37	86.15	81.09	80.84	77.90	77.51	78.51	78.74	78.14	77.24	75.69	73.74	
Swine	2021	117.12	89.92	95.08	98.23	93.21	94.56	97.47	96.29	97.28	94.06	93.26	93.92	90.54	88.50
	2020	117.12	89.92	95.08	98.23	93.21	94.58	97.51	96.36	97.37	94.17	93.40	94.09	90.63	
poultry	2021	22.96	21.99	24.87	26.65	26.06	28.23	30.34	31.50	31.80	31.84	31.68	31.95	32.45	32.43
	2020	22.71	21.41	23.86	25.36	24.55	26.63	28.81	30.02	30.27	30.31	30.21	30.46	30.87	
Other animals	2021	9.59	11.16	9.37	9.43	8.43	8.18	8.16	8.07	8.00	7.89	7.79	7.72	7.62	7.51
	2020	9.44	11.02	9.25	9.31	8.33	8.09	8.07	7.98	7.91	7.80	7.71	7.64	7.53	
NOx emissions from manure management, in Gg															
Total	2021	1.720	1.551	1.523	1.534	1.529	1.502	1.480	1.475	1.482	1.465	1.455	1.444	1.418	1.401
	2020	1.863	1.674	1.639	1.644	1.632	1.604	1.582	1.579	1.588	1.572	1.562	1.548	1.519	
Dairy cattle	2021	0.671	0.597	0.570	0.552	0.521	0.513	0.495	0.491	0.493	0.495	0.494	0.489	0.488	0.489
	2020	0.722	0.640	0.601	0.580	0.549	0.541	0.523	0.521	0.525	0.528	0.527	0.522	0.520	
Other cattle	2021	0.696	0.614	0.600	0.566	0.562	0.538	0.529	0.532	0.532	0.526	0.519	0.509	0.497	0.487
	2020	0.788	0.695	0.685	0.649	0.637	0.611	0.602	0.606	0.606	0.601	0.593	0.581	0.566	
Swine	2021	0.264	0.242	0.263	0.322	0.351	0.355	0.359	0.353	0.357	0.344	0.343	0.346	0.335	0.328
	2020	0.264	0.242	0.263	0.322	0.351	0.355	0.359	0.353	0.357	0.344	0.343	0.346	0.334	
poultry	2021	0.026	0.024	0.028	0.033	0.040	0.043	0.045	0.047	0.048	0.048	0.048	0.048	0.049	0.049
	2020	0.026	0.024	0.028	0.033	0.040	0.043	0.045	0.047	0.048	0.048	0.048	0.048	0.049	
Other animals	2021	0.063	0.073	0.062	0.062	0.055	0.053	0.053	0.053	0.052	0.051	0.051	0.050	0.050	0.049
	2020	0.063	0.073	0.062	0.062	0.055	0.053	0.053	0.053	0.052	0.051	0.051	0.050	0.050	

Planned improvements

No improvements are planned at present.

NMVOC

In 2019, NMVOC emissions from manure management amount to xx316.5 which is xx97.6 % of total NMVOC emissions from the agricultural sector. xx85.7 % originate from cattle, xx4.5 % from pigs, and xx8.7 % from poultry. All NMVOC emissions from the agricultural sector are excluded from emission accounting by adjustment as they are not considered in the NEC and Gothenburg commitments (see Chapter 11 - Adjustments and Emissions Reduction Commitments).

Method

The Tier 2 methodology provided by EMEP (2016)-3B-25 [10] was used to assess the NMVOC emissions from manure management for dairy cattle and other cattle. For all other animals the Tier 1 methodology (EMEP (2016)-3B-17 [10]) was used.

Activity data

Animal numbers serve as activity data, see Table 1.

Emission factors

For the Tier 2 methodology applied to dairy cattle and other cattle the following data was used:

- gross feed intake in MJ per year, country specific data from the annual reporting of greenhouse gas emissions, see NIR 2020, Chapter 5.1.3.3,
- proportion x house of the year the animals spend in the livestock building: country specific data, being equal to 1 – xgraz with xgraz the proportion of the year spent on pasture, see NIR 2020, Chapter 19.3.2,
- FRACsilage 1 as proposed by EMEP (2016)-3B-27 [10], since silage feeding for cattle is considered dominant in Germany
- FRACsilage store: 0.25 as proposed by EMEP (2016)-3B-28 [10] for European conditions
- EFNMVOC silage_feeding, EFNMVOC, house, EFNMVOC, graz are taken from EMEP (2016)-3B-30, table 3.11 [10] as 0.0002002, 0.0000353 and 0.0000069 kg NMVOC/MJ feed intake, respectively,
- EFNH3,storage, EFNH3,building, and EFNH3,application are taken from the NH3 reporting (see above and 3.D).

For all other animal categories the Tier 1 emission factors for NMVOC as provided in EMEP (2016)-3B-18, Table 3.4 [10] were used: For horses the emission factors for feeding with silage was chosen, for all other animals the emission factors for feeding without silage. Due to missing country-specific emission factors or emission factors that do not correspond to the inventory's animal categories, the emission factors provided in EMEP (2016)-3B-18, Table 3.4, were used to define specific emission factors for weaners, boars, lambs, ponies/light horses and pullets, see Haenel et al. (2020), Chapter 3.3.4.2 [1]. The implied emission factors given in Table 4 relate the overall NMVOC emissions to the number of animals in each animal category. The IEFs for dairy cattle and other cattle are identical to the EMEP Tier 2 EF and are much higher than the EMEP Tier 1 EF, which are 17.937 kg NMVOC for dairy cattle and 8.902 kg NMVOC for other cattle. The only possible explanation for those

huge differences is that the EMEP Tier 2 and Tier 1 methods are not consistent.

The IEFs for the other categories provided in Table 4 correspond to the EMEP Tier 1 emission factors, except for horses, sheep, swine and other poultry. These categories comprise subcategories with different emission factors so that their overall IEFs in Table 4 represent subpopulation-weighted national mean values. Note that other poultry in Germany includes not only geese and ducks but also pullets. For pullets no default EF is given in the EMEP guidebook (EMEP, 2016) [10] , hence the EF of broilers has been adopted (because of similar housing). This assumption significantly lowers the overall IEF of other poultry in Table 4 the IEFs are listed separately for each poultry category). The IEF of the sheep category is significantly lower than the EMEP Tier 1 emission factor, because for lambs the EF is assumed to be 40% lower compared to an adult sheep in accordance with the difference in N excretion between lambs and adult sheep.

Table 4: IEF for NMVOC from manure management

IEF in kg NMVOC per animal place														
	1990	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
dairy cattle	30.940	32.695	35.473	36.706	37.234	37.578	37.560	37.351	37.721	37.914	38.366	38.378	39.213	40.093
other cattle	11.705	11.657	11.765	11.652	11.722	11.676	11.646	11.654	11.602	11.616	11.618	11.658	11.716	11.818
horses	6.497	6.491	6.688	6.660	6.644	6.643	6.642	6.641	6.644	6.646	6.648	6.651	6.653	6.656
sheep	0.131	0.131	0.132	0.132	0.131	0.131	0.131	0.131	0.131	0.131	0.131	0.131	0.131	0.131
goats	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542
swine	0.695	0.698	0.690	0.682	0.669	0.663	0.656	0.654	0.652	0.651	0.649	0.648	0.648	0.648
laying hens	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165
broilers	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108
turkeys	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489
pullets	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108
ducks	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489
geese	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489	0.489

Trend discussion for Key Sources

Dairy cattle and other cattle are key sources of NMVOC emissions from manure management. The total NMVOC emissions from both animal categories strongly correlate with the animal numbers given in Table 1 (cattle: R^2 = 0.98; other cattle: R^2 = 0.99).

Recalculations

All time series of the emission inventory have completely been recalculated since 1990. Table REC-3 compares the recalculated time series of the NMVOC emissions from 3.B with the respective data of last year's submission. The recalculated total emissions are by more than 60 % higher. This is completely due to the introduction of the Tier 2 methodology for cattle (recalculation No 1, see main page of the agricultural sector (https://iir-de-2020.wikidot.com/3-agriculture)), which more than doubles the dairy cattle emissions calculated with the Tier 1 method. Emissions from other cattle are more than 40 % higher than those calculated with the Tier 1 method for last year's submission. As mentioned already above, that huge differences are due to the fact that the Tier 2 and Tier 1 methods are not consistent. Emissions of other species remained unchanged, **with the exception of laying hens emissions in 2017**, due to **recalculation No 8**. Further details on recalculations are described in Haenel et al. (2020), Chapter 3.5.2 [1].

Table REC-3: Comparison of NMVOC emissions of the submissions (SUB) 2020 and 2021

NMVOC emissions from manure management, in Gg															
	SUB	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Total	2021	390.80	332.18	318.01	297.65	296.79	297.13	299.17	304.38	306.74	305.38	303.07	300.94	297.86	295.83
	2020	439.44	365.76	344.98	320.23	317.25	317.26	318.95	324.80	326.92	325.45	322.84	320.20	316.49	
Dairy cattle	2021	196.61	170.97	162.10	155.50	155.75	157.45	157.39	159.40	162.04	162.45	161.82	161.15	160.81	160.84
	2020	231.88	194.00	177.13	167.50	166.57	168.13	167.69	170.01	172.37	172.58	171.57	170.89	169.97	
Other cattle	2021	153.72	124.27	117.29	102.54	101.14	97.38	96.89	98.11	98.00	97.00	95.83	94.23	91.95	90.15
	2020	167.09	134.83	129.24	113.12	110.78	106.84	106.37	107.92	107.84	106.95	105.84	103.75	101.42	
Other animals	2021	40.46	36.94	38.62	39.61	39.89	42.29	44.89	46.87	46.70	45.93	45.42	45.56	45.11	44.84
	2020	40.46	36.94	38.62	39.61	39.89	42.29	44.89	46.87	46.70	45.93	45.42	45.56	45.11	

Planned improvements

No improvements are planned at present.

TSP, PM10 and PM2.5

In 2019, TSP emissions from manure management amount to xx71.4 % of total emissions from the agricultural sector. Within the emissions from manure management xx22.6 % originate from cattle, xx39.8 % from pigs, and xx37.0 % from poultry. xx43.0 % of the PM<ub>10</sub> emissions from the agricultural sector are caused by manure management, where xx34.4 % originate from cattle, xx19.2 % from pigs, and xx45.6 % from poultry. $PM_{2.5}$ emissions from the agricultural sector mostly originate from manure management (xx85.0 %), of which are xx77.8 % from cattle, xx3.0 % from pigs, and xx17.6 % from poultry.

Method

EMEP (2013)-3B-26 [9] provided a Tier 2 methodology. In the current Guidebook (EMEP, 2016) [10], this methodology has been replaced by a Tier 1 methodology. However, EF for cattle derived with the EMEP 2013 Tier 2 methodology remained unchanged. So the EMEP 2013 [9] methodology was kept for cattle. For swine the EMEP 2013 [9] methodology was formally kept but the EMEP 2016 Tier 1 EF was used both for slurry and solid based manure management systems. The same was done with the EMEP 2016 EFs for laying hens (used for cages and perchery). In case the EMEP 2016 EFs are just the rounded EMEP 2013 EFs, the unrounded EMEP 2013 EFs were kept. The inventory considers air scrubber systems in swine and poultry husbandry. For animal places equipped with air scrubbing the emission factors are reduced according to the removal efficiency of the air scrubber systems (90 % for TSP and PM_{10}, 70 % for $PM_{2.5}$). For details see Haenel et al. (2020), Chapter 3.3.4.3.3 [1].

Activity data

Animal numbers serve as activity data, see Table 1.

Emission factors

Tier 1 emission factors for TSP, PM_{10} and $PM_{2.5}$ from livestock husbandry are provided in EMEP (2016)-3B-19, Table 3.5 and 53, Table A3-4 [10]. For cattle the Tier 2 emission factors provided in EMEP (2013)-3B-29, Table 3-11 [9] were used, because they differentiate between slurry and solid

manure systems and were also used to develop the EMEP 2016 Tier 1 emissions factors.

The implied emission factors given in Table 5 relate the overall TSP and PM emissions to the number of animals in each animal category. The Guidebook does not indicate whether EFs have considered the condensable component (with or without).

Table 5: IEF for TSP, PM_{10} & $PM_{2.5}$ from manure management

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
IEF in kg TSP per animal place														
dairy cattle	1.2124	1.4016	1.4544	1.4743	1.4891	1.4873	1.4860	1.4841	1.4840	1.4828	1.4834	1.4828	1.4826	1.4826
other cattle	0.5194	0.5107	0.5018	0.4926	0.4823	0.4814	0.4817	0.4822	0.4813	0.4806	0.4807	0.4807	0.4810	0.4807
horses	0.3514	0.3512	0.3558	0.3552	0.3548	0.3548	0.3548	0.3548	0.3548	0.3549	0.3549	0.3550	0.3550	0.3551
sheep	0.0484	0.0478	0.0489	0.0486	0.0489	0.0485	0.0485	0.0485	0.0483	0.0482	0.0482	0.0482	0.0480	0.0482
goats	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914	0.0914
swine	0.8260	0.8366	0.8320	0.8247	0.8104	0.8043	0.8086	0.8037	0.8002	0.7910	0.7918	0.7891	0.7865	0.7814
laying hens	0.1900	0.1900	0.1900	0.1900	0.1900	0.1900	0.1900	0.1900	0.1900	0.1899	0.1898	0.1897	0.1894	0.1890
broilers	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0399	0.0399	0.0397	0.0396	0.0395	0.0394
turkeys	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100
pullets	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400
ducks	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400
geese	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400
IEF in kg PM_{10} per animal place														
dairy cattle	0.5557	0.6426	0.6668	0.6759	0.6827	0.6819	0.6813	0.6804	0.6803	0.6798	0.6801	0.6798	0.6797	0.6797
other cattle	0.2403	0.2363	0.2321	0.2278	0.2230	0.2226	0.2227	0.2229	0.2225	0.2222	0.2222	0.2222	0.2223	0.2222
horses	0.1619	0.1619	0.1639	0.1636	0.1634	0.1634	0.1634	0.1634	0.1634	0.1634	0.1635	0.1635	0.1635	0.1635
sheep	0.0194	0.0192	0.0196	0.0195	0.0196	0.0195	0.0194	0.0194	0.0194	0.0193	0.0193	0.0193	0.0192	0.0193
goats	0.0368	0.0368	0.0368	0.0368	0.0368	0.0368	0.0368	0.0368	0.0368	0.0368	0.0368	0.0368	0.0368	0.0368
swine	0.1241	0.1255	0.1244	0.1230	0.1199	0.1187	0.1185	0.1177	0.1170	0.1158	0.1156	0.1151	0.1147	0.1139
laying hens	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0400	0.0399	0.0399	0.0398
broilers	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0199	0.0198	0.0198	0.0198	0.0197
turkeys	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100
pullets	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200
ducks	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400	0.1400
geese	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400	0.2400
IEF in kg $PM_{2.5}$ per animal place														
dairy cattle	0.3616	0.4181	0.4339	0.4398	0.4442	0.4437	0.4433	0.4427	0.4427	0.4423	0.4425	0.4423	0.4422	0.4422
other cattle	0.1574	0.1548	0.1521	0.1493	0.1463	0.1460	0.1461	0.1462	0.1460	0.1458	0.1458	0.1458	0.1459	0.1458
horses	0.1027	0.1026	0.1039	0.1038	0.1036	0.1036	0.1036	0.1036	0.1036	0.1037	0.1037	0.1037	0.1037	0.1037
sheep	0.0059	0.0059	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0059	0.0059	0.0059	0.0059	0.0059	0.0059
goats	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112	0.0112
swine	0.0056	0.0057	0.0056	0.0056	0.0054	0.0054	0.0053	0.0053	0.0053	0.0052	0.0052	0.0052	0.0052	0.0052
laying hens	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030
broilers	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
turkeys	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200	0.0200
pullets	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020
ducks	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180	0.0180
geese	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320	0.0320

Trend discussion for Key Sources

Swine and laying hens are key sources of TSP emissions from manure management. The total TSP emissions from swine mainly follow the animal numbers given in Table 1. However, due to different emission factors of the different housing systems of the four swine subcategories (sows with piglets, weaners, fattening pigs, boars) and the varying population shares in those housing systems the R^2 of the linear regression is lower than 1 (0.82). For laying hens, TSP emissions perfectly correlate with the animal numbers provided in Table 1 ($R^2 = 1$).

Recalculations

Table REC-4 shows the effects of recalculations on emissions of particulate matter. The overall recalculation effects are small. The biggest impact has the introduction of air scrubber systems only affecting particulate matter emissions for swine (recalculation No 6, see main page of the agricultural sector (https://iir-de-2020.wikidot.com/3-agriculture)) and, to a lesser extent, the introduction of air scrubber systems for poultry (No 7). More details on the agricultural recalculations can be found on the main agricultural page (https://iir-de-2020.wikidot.com/3-agriculture). Further details on recalculations are described in Haenel et al. (2020), Chapter 3.5.2.

Table REC-4: Comparison of particle emissions (TSP, PM_{10} & $PM_{2.5}$) of the submissions (SUB) 2020 and 2021

	TSP, PM10, PM2.5 emissions from manure management, in Gg													
	SUB	**1990**	**1995**	**2000**	**2005**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
TSP	**2021**	50.04	42.24	42.44	41.26	40.32	41.79	43.90	45.06	45.33	44.58	44.35	44.40	43.55	42.90
TSP	**2020**	50.26	42.41	42.44	41.26	40.32	41.79	43.91	45.07	45.36	44.61	44.39	44.44	43.62	
PM_{10}	**2021**	14.34	12.71	12.63	12.29	12.32	12.75	13.31	13.80	13.77	13.56	13.39	13.36	13.17	13.00
PM_{10}	**2020**	14.44	12.78	12.63	12.29	12.32	12.75	13.31	13.80	13.78	13.57	13.40	13.38	13.19	
$PM_{2.5}$	**2021**	5.01	4.47	4.18	3.89	3.86	3.86	3.91	4.01	4.01	3.97	3.91	3.88	3.80	3.72
$PM_{2.5}$	**2020**	5.08	4.52	4.18	3.89	3.86	3.86	3.91	4.01	4.01	3.97	3.91	3.88	3.80	

Planned improvements

No improvements are planned at present.

Uncertainty

Details will be described in chapter 1.7.