

## 3.B - Manure Management

### Short description

NFR-Code	Name of Category	Method	AD	EF
3.B	Manure Management	see sub-category details		
consisting of / including source categories				
3.B.1.a & 3.B.1.b	Cattle	T3 (NH <sub>3</sub> ), T2 (NO <sub>x</sub> , TSP, PM <sub>10</sub> , PM <sub>2.5</sub> , NMVOC)	NS, RS	CS (NH <sub>3</sub> , NO <sub>x</sub> ), D (TSP, PM <sub>10</sub> , PM <sub>2.5</sub> , NMVOC)
3.B.2, 3.B.4.d, 3.B.4.e	Sheep, Goats, Horses	T2 (NH <sub>3</sub> , NO <sub>x</sub> , TSP, PM <sub>10</sub> , PM <sub>2.5</sub> ), T1 (NMVOC)	NS, RS	CS (NH <sub>3</sub> ,NO <sub>x</sub> ), D (TSP, PM <sub>10</sub> , PM <sub>2.5</sub> , NMVOC)
3.B.3	Swine	T3 (NH <sub>3</sub> ), T2 (NO <sub>x</sub> , TSP, PM <sub>10</sub> , PM <sub>2.5</sub> ), T1 (NMVOC)	NS, RS	CS (NH <sub>3</sub> , NO <sub>x</sub> ), D (TSP, PM <sub>10</sub> , PM <sub>2.5</sub> , NMVOC)
3.B.4.a	Buffalo	until 1995: NO, since 1996: IE (in 3.B.1.b)		
3.B.4.f	Mules and asses	IE (in 3.B.4.e)		
3.B.4.g i-iv	Poultry	T2 (NH <sub>3</sub> , NO <sub>x</sub> , TSP, PM <sub>10</sub> , PM <sub>2.5</sub> ), T1 (NMVOC)	NS, RS	CS (NH <sub>3</sub> , NO <sub>x</sub> ), D (TSP, PM <sub>10</sub> , PM <sub>2.5</sub> , NMVOC)
3.B.4.h	Other animals (Deer, Rabbits, Ostrich)	T2 (NH <sub>3</sub> , NO <sub>x</sub> ), T1 (TSP, PM <sub>10</sub> , PM <sub>2.5</sub> , NMVOC)	AS, M	CS (NH <sub>3</sub> , NO <sub>x</sub> ), D (TSP, PM <sub>10</sub> , PM <sub>2.5</sub> , NMVOC)

	NO <sub>x</sub>	NMVOC	SO <sub>2</sub>	NH <sub>3</sub>	PM <sub>2.5</sub>	PM <sub>10</sub>	TSP	BC	CO	Heavy Metals	PAHs	HCB	PCBs
3.B.1.a	-/-	L/-	NA	L/-	L/-	-/-	-/-	NA	NA	NA	NA	NA	NA
3.B.1.b	-/-	L/T	NA	L/T	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA
3.B.2	-/-	-/-	NA	-/-	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA
3.B.3	-/-	-/-	NA	L/T	-/-	-/-	L/-	NA	NA	NA	NA	NA	NA
3.B.4.d	-/-	-/-	NA	-/-	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA
3.B.4.e	-/-	-/-	NA	-/-	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA
3.B.4.g.i	-/-	-/-	NA	-/-	-/-	-/-	L/-	NA	NA	NA	NA	NA	NA
3.B.4.g.ii	-/-	-/-	NA	-/-	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA
3.B.4.g.iii	-/-	-/-	NA	-/-	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA
3.B.4.g.iv	-/-	-/-	NA	-/-	-/-	-/-	-/-	NA	NA	NA	NA	NA	NA

#### Method(s) applied

<b>D</b>	Default
<b>T1</b>	Tier 1 / Simple Methodology *
<b>T2</b>	Tier 2*
<b>T3</b>	Tier 3 / Detailed Methodology *
<b>C</b>	CORINAIR
<b>CS</b>	Country Specific
<b>M</b>	Model

\* as described in the EMEP/EEA Emission Inventory Guidebook - 2019, in category chapters.

#### (source for) Activity Data

<b>NS</b>	National Statistics
<b>RS</b>	Regional Statistics
<b>IS</b>	International Statistics
<b>PS</b>	Plant Specific
<b>As</b>	Associations, business organisations
<b>Q</b>	specific Questionnaires (or surveys)
<b>M</b>	Model / Modelled
<b>C</b>	Confidential

#### (source for) Emission Factors

<b>D</b>	Default (EMEP Guidebook)
<b>CS</b>	Country Specific
<b>PS</b>	Plant Specific
<b>M</b>	Model / Modelled

## Country specifics



In 2023,  $\text{NH}_3$  emissions from category 3.B (manure management) were 37.3 % from total agricultural emissions, which is equal to  $\sim 196.5$  kt  $\text{NH}_3$ . Within those emissions 46.5 % originate from cattle manure ( $\sim 91.3$  kt), 31.6 % from pig manure (ca. 62.1 kt), and 11.7 % from poultry manure ( $\sim 22.9$  kt). Calculations take into account the impact of anaerobic digestion of manure on the emissions.

$\text{NO}_x$  emissions from category 3.B (manure management) contribute only 1.6 % ( $\sim 1.6$  kt) to the total agricultural  $\text{NO}_x$  emissions. They are calculated proportionally to  $\text{N}_2\text{O}$  emissions, see Rösemann et al. (2025) <sup>1)</sup>.

NMVOC emissions from category 3.B (manure management) contributed 96.9 % (292.1 kt) from total agricultural NMVOC emissions (301.3 kt).

In 2023, manure management contributed, respectively, 61.2 % (37.3 kt), 33.0 % (11.7 kt) and 66.3 % (3.6 kt) to the total agricultural TSP,  $\text{PM}_{10}$  and  $\text{PM}_{2.5}$  emissions (TSP: 61.0 kt,  $\text{PM}_{10}$ : 35.4 kt,  $\text{PM}_{2.5}$ : 5.4 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 Rösemann et al, 2025, Chapter 2.3.

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 Rösemann et al. (2025), Chapter 2.3. 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 2023, dairy cattle numbers are 58.4 % of 1990 numbers, while the total population of other cattle is at 54.2 % of 1990. Swine numbers decreased until 1995 and then increased slightly. Since 2014 a new decrease occurred which became significant between 2020 and 2022 (total pig numbers were reduced by around 18 % within two years). In 2023 this trend did not continue. 2023 swine numbers are 66.1 % of 1990 numbers. The 2022 numbers of horses, sheep and goats are, respectively, at 97.4 %, 56.6 % and 180.7 % of 1990.

Figures for broilers and turkeys are showing a massive increase since 1990. Since the year 2013, there have been only minor changes of total poultry numbers. In total, 2023 poultry population figures are at 146.9 % of 1990.

Emissions of deer, rabbits, ostrich and fur-bearing animals are reported since submission 2024. The underlying animal numbers of these categories were estimated in different ways because there are no surveys which collect those animal numbers. However, the impact of those animal categories on the total emissions is small.

A detailed description of the animal numbers used can be found in Rösemann et al. (2025), chapter 2.3.

Table 1: Population of animals, in [1,000 individuals]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
<b>dairy cattle</b>	6.354,6	5.229,4	4.569,8	4.236,4	4.183,1	4.284,6	4.217,7	4.199,0	4.100,9	4.011,7	3.921,4	3.832,7	3.809,7	3.712,8
<b>other cattle</b>	13.133,4	10.660,5	9.968,9	8.800,4	8.628,7	8.350,8	8.248,9	8.082,2	7.848,2	7.627,9	7.380,5	7.206,9	7.187,2	7.123,4
<b>buffalo</b>	NO	NO	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
<b>mules and asses</b>	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE	IE
<b>horses</b>	1.373,5	1.743,9	1.373,7	1.398,1	1.269,9	1.233,1	1.215,4	1.223,4	1.231,5	1.239,5	1.247,6	1.277,8	1.308,0	1.338,2
<b>sheep</b>	3.266,1	2.990,7	2.743,3	2.643,1	2.245,0	1.866,9	1.851,0	1.863,2	1.846,0	1.813,6	1.780,3	1.794,8	1.805,7	1.847,6
<b>goats</b>	90,0	100,0	140,0	170,0	149,9	135,9	138,8	142,8	146,9	150,9	154,9	157,5	160,0	162,6
<b>swine</b>	26.502,5	20.387,3	21.767,7	22.742,8	22.244,4	22.978,5	22.761,2	22.920,8	22.019,2	21.596,4	21.622,0	19.728,6	17.692,3	17.525,3
<b>laying hens</b>	53.450,5	47.575,8	48.640,0	43.641,6	41.700,5	50.619,3	51.935,5	52.571,1	53.206,6	53.842,1	54.477,6	54.921,5	55.365,4	55.809,3
<b>broilers</b>	35.393,0	46.625,9	61.940,7	76.045,0	98.389,7	94.909,4	93.791,3	93.458,7	93.126,1	92.793,5	92.461,0	91.004,5	89.548,1	88.091,6
<b>turkeys</b>	5.029,2	6.742,0	8.893,1	10.611,1	11.344,0	12.658,5	12.359,9	12.164,7	11.969,5	11.774,3	11.579,1	10.718,9	9.858,6	8.998,3
<b>pullets</b>	17.210,8	16.149,2	17.284,1	16.050,9	14.827,0	13.828,3	12.921,8	12.736,3	12.550,7	12.365,1	12.179,6	12.253,0	12.326,5	12.399,9
<b>ducks</b>	2.013,7	1.933,7	2.055,7	2.352,2	3.164,3	2.410,8	2.236,4	2.209,1	2.181,9	2.154,6	2.127,4	1.949,3	1.771,2	1.593,1
<b>geese</b>	781,5	617,0	404,8	329,5	278,1	400,8	329,0	327,7	326,3	324,9	323,5	354,2	385,0	415,7
<b>deer</b>	155,8	204,0	252,3	261,5	270,7	279,9	281,7	283,5	285,4	287,2	289,1	290,9	292,7	294,6
<b>rabbits</b>	1.851,4	1.565,6	1.268,9	997,0	864,2	720,7	691,2	642,7	608,3	593,9	548,4	470,0	430,6	422,8
<b>ostrich</b>	NO	1,2	2,5	3,7	4,9	7,7	7,4	7,4	7,9	7,4	7,9	6,1	5,1	4,6
<b>fur animals</b>	179,9	179,9	179,9	153,5	121,7	34,4	24,7	15,0	5,3	5,3	NO	NO	NO	NO

Other animals: no data available

## 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 Rösemann et al. (2025), Chapter 2.

Most of the data regarding feed and performance is not available from official statistics and was obtained from literature, from publications by agricultural associations, 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 UmweltInformationssystem 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)<sup>2)</sup>; a detailed description is provided in Henrichsmeyer et al. (1996)<sup>3)</sup>.

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 the respective years. For 1990, the data for 1991 is adopted, for the intervening years (1992-1994 and 1996-1998) data gaps were closed by linear interpolation on district level.

For the year 2009, 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). The gaps between the latest RAUMIS model data (1999) and the first official data (2009) were closed by linear interpolation on district level.

The data from the 2020 official agricultural census (DESTATIS, 2020)<sup>4)</sup> is being used for subsequent years until more current data is available.

## NH<sub>3</sub> and NO<sub>x</sub>

## N in manure management

In order to determine  $\text{NH}_3$  and  $\text{NO}_x$  emissions from manure management of a specific animal category, the individual N excretion rate must be known as well as, for  $\text{NH}_3$ , 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, 2023<sup>51</sup>. However, the German agricultural emission inventory uses N mass balances to calculate the N excretions and the TAN contents of almost all reported animal categories. 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 Rösemann et al. (2025). Chapter 4.2 as well as Chapter 4.1.2.

[illegible]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
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	72.0	71.7	71.1	71.8	72.3	71.6	71.4	71.2	71.1	71.0	70.8	70.9	70.8	70.6
laying hens	70.2	69.6	69.0	69.3	70.0	70.2	70.1	70.1	70.2	70.2	70.1	70.1	70.2	70.3
broilers	60.8	58.9	56.4	53.5	50.0	46.9	46.5	46.1	45.7	45.2	44.8	44.8	44.8	44.8
turkeys	64.7	64.7	63.0	63.9	63.0	63.5	63.5	63.5	63.0	63.0	62.1	62.1	62.1	62.1
pullets	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4	69.4
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
deer	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
rabbits	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
ostrich	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
fur animals	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

### N mass flow and emission assessment

The calculation of the emissions of  $\text{NH}_3$ ,  $\text{N}_2\text{O}$ ,  $\text{NO}_x$  and  $\text{N}_2$  from German animal husbandry is based on the so-called N mass flow approach (e. g. Dämmgen and Hutchings, 2008<sup>6)</sup>). This approach differentiates between N excreted with faeces (organic nitrogen  $\text{N}_{\text{org}}$ , 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  $\text{NH}_3$  emissions (EMEP, 2023), and the IPCC guidelines for greenhouse gas emissions (IPCC (2006)<sup>7)</sup>. Reidy et al. (2008),<sup>8)</sup> 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 further 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 ( $E_{\text{yard}}$   $\text{NH}_3$  emissions from yards;  $E_{\text{house}}$   $\text{NH}_3$  emissions from house;  $E_{\text{storage}}$   $\text{NH}_3$ ,  $\text{N}_2\text{O}$ ,  $\text{NO}_x$  and  $\text{N}_2$  emissions from storage;  $E_{\text{applic}}$   $\text{NH}_3$  emissions during and after spreading;  $E_{\text{graz}}$   $\text{NH}_3$ ,  $\text{N}_2\text{O}$ ,  $\text{NO}_x$  and  $\text{N}_2$  emissions during and

after grazing;  $E_{soil}$   $N_2O$ ,  $NO_x$  and  $N_2$  emissions from soil resulting from manure input).

The model 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 through the livestock systems are represented. During storage Norg can be transformed into TAN and vice versa. Both, the way and the magnitude 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 Rösemann et al. (2025), Chapter 4.2. Wherever  $NH_3$  is emitted, its formation is related to the amount of the TAN present.  $N_2O$  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  $N_2$  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 model 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) supplemented by data from the 2020 agricultural census. The average removal efficiency of  $NH_3$  is 80 % for swine and 70 % for poultry, while for TSP and  $PM_{10}$  the rates are set to 90 % and for  $PM_{2.5}$  to 70 % for both animal categories. For swine two types of air scrubbers are distinguished: systems of "first class" that remove both  $NH_3$  and particles, and "second class" systems that remove only particles reliably and have a  $NH_3$  removal efficiency of 20%.

According to KTBL, 7.6 % of all pig places were equipped with "first class" systems in 2023, another 12.6 % were equipped with "second class" systems. For poultry 0.9 % of all laying hen places and 2.4 % 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 Rösemann et al. (2025), Chapter 4.2.2.

#### **Anaerobic digestion of manure**

According to IPCC (2006), anaerobic digestion of manure is treated like a particular storage type. In the German Inventory it comprises three sub-compartments (pre-storage, fermenter and storage of digestates). For details see Rösemann et al. (2025), Chapters 2.6 and 4.2.5. The resulting digestates are considered as liquid. Two different types of digestates storage systems are considered: gastight storage and open tank. For open tanks formation of a natural crust because of co-fermentation with 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 application of digestates ( $NH_3$  emissions and NO emissions from application 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  $N_2$  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 (2023). No specific  $NH_3$  emission factors are known for the application of digested manure. However, due to co-fermentation with 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 Rösemann et al. (2025), Chapter 4.3.

Table 3 provides, by animal category, the implied  $NH_3$  emission factors for manure management (housing and storage). The overall German  $NH_3$  IEF for manure application is reported in section 3.D.a.2.a.

The detailed emission factors for  $N_2O$ ,  $NO_x$  and  $N_2$  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<sub>2</sub>O emission factors are taken from IPCC (2006). The emission factors for NO<sub>x</sub> and N<sub>2</sub> are approximated as being proportional to the N<sub>2</sub>O emission factors, i.e. the NO-N and N<sub>2</sub> emission factors are, respectively, one-tenth and three times the value of the N<sub>2</sub>O-N emission factor, see Rösemann et al. (2025), chapter 4.2.4. This proportionality is also applied to anaerobic digestion of manure, where N<sub>2</sub>O 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). Note that the inventory model calculates NO rather than NO<sub>x</sub>. The conversion of NO emissions into NO<sub>x</sub> emissions is achieved by multiplying the NO emissions with the NO<sub>2</sub>/NO molar weight ratio of 46/30. This relationship also holds for NO and NO<sub>x</sub> emission factors.

Table 3 shows the implied emission factors of NH<sub>3</sub> and NO<sub>x</sub> 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<sub>3</sub> & NO<sub>x</sub> from manure management, in [kg per animal place]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
<b>Ammonia</b>														
<b>dairy cattle</b>	9.5	9.7	10.4	11.3	11.7	11.9	12.1	12.1	12.3	12.6	12.7	12.7	12.6	12.8
<b>other cattle</b>	5.7	5.8	5.9	6.2	6.6	6.3	6.2	6.2	6.1	6.1	6.1	6.1	6.1	6.1
<b>horses</b>	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
<b>sheep</b>	0.83	0.82	0.84	0.83	0.84	0.83	0.83	0.83	0.82	0.83	0.83	0.82	0.82	0.82
<b>goats</b>	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
<b>swine</b>	4.54	4.44	4.32	4.24	4.05	3.82	3.77	3.72	3.69	3.63	3.59	3.63	3.54	3.54
<b>laying hens</b>	0.213	0.205	0.210	0.208	0.136	0.129	0.128	0.127	0.125	0.124	0.122	0.122	0.121	0.121
<b>broilers</b>	0.143	0.108	0.104	0.098	0.088	0.091	0.091	0.090	0.091	0.089	0.086	0.086	0.085	0.087
<b>turkeys</b>	0.797	0.797	0.800	0.877	0.836	0.848	0.848	0.849	0.825	0.824	0.772	0.773	0.763	0.762
<b>pullets</b>	0.125	0.116	0.106	0.105	0.101	0.094	0.094	0.095	0.096	0.096	0.095	0.097	0.095	0.096
<b>ducks</b>	0.193	0.193	0.193	0.192	0.189	0.182	0.182	0.182	0.182	0.182	0.182	0.183	0.182	0.182
<b>geese</b>	0.386	0.386	0.385	0.384	0.381	0.377	0.377	0.377	0.377	0.377	0.376	0.377	0.376	0.377
<b>deer</b>	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
<b>rabbits</b>	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228	0.228
<b>ostrich</b>	1.765	1.765	1.765	1.765	1.765	1.765	1.765	1.765	1.765	1.765	1.765	1.765	1.765	1.765
<b>fur animals</b>	1.123	1.123	1.123	1.123	1.123	1.123	1.123	1.123	1.123	1.123	1.123	1.123	1.123	1.123
<b>Nitrogen oxides</b>														
<b>dairy cattle</b>	0.140	0.135	0.147	0.155	0.152	0.142	0.142	0.141	0.143	0.145	0.145	0.143	0.143	0.147
<b>other cattle</b>	0.064	0.068	0.071	0.076	0.079	0.078	0.078	0.078	0.078	0.079	0.079	0.078	0.078	0.078
<b>horses</b>	0.169	0.169	0.172	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171	0.171
<b>sheep</b>	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
<b>goats</b>	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
<b>swine</b>	0.014	0.016	0.015	0.016	0.017	0.014	0.014	0.014	0.014	0.013	0.013	0.013	0.013	0.013
<b>laying hens</b>	0.00027	0.00026	0.00025	0.00029	0.00035	0.00035	0.00035	0.00035	0.00034	0.00033	0.00032	0.00031	0.00031	0.00031
<b>broilers</b>	0.00016	0.00012	0.00012	0.00013	0.00014	0.00016	0.00016	0.00016	0.00016	0.00015	0.00014	0.00014	0.00014	0.00015
<b>turkeys</b>	0.00068	0.00068	0.00071	0.00085	0.00094	0.00097	0.00095	0.00094	0.00090	0.00087	0.00080	0.00077	0.00078	0.00078
<b>pullets</b>	0.00013	0.00012	0.00011	0.00012	0.00014	0.00014	0.00014	0.00014	0.00014	0.00013	0.00013	0.00012	0.00012	0.00012
<b>ducks</b>	0.00024	0.00024	0.00024	0.00026	0.00027	0.00028	0.00028	0.00028	0.00027	0.00027	0.00026	0.00025	0.00025	0.00025
<b>geese</b>	0.00025	0.00025	0.00025	0.00028	0.00032	0.00032	0.00031	0.00031	0.00030	0.00029	0.00028	0.00027	0.00027	0.00027
<b>deer</b>	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
<b>rabbits</b>	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269	0.00269
<b>ostrich</b>	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126	0.00126
<b>fur animals</b>	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508	0.01508

#### Trend discussion for Key Sources

Dairy cattle, other cattle and swine are key sources of NH<sub>3</sub> emissions from manure management. The time series of the total NH<sub>3</sub> emissions from all three categories are predominantly driven by the development of the animal numbers, see Table 1. 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. Increasing dairy cattle emissions since 2010 are also due to a sharp decline of tied housing systems, which have a lower NH<sub>3</sub> emission factor than loose housing systems. For swine the IEF is decreasing over time due to lower raw protein contents in feed and the use of air scrubbing systems that, to a high degree, remove NH<sub>3</sub> from the housings.

For NO<sub>x</sub> there are no key categories.

### Recalculations

All timeseries of the emission inventory have completely been recalculated. Tables REC-1 and REC-2 compare the recalculated time series for NH<sub>3</sub> and NO<sub>x</sub> from 3B with the respective data of last year's submission.

For NH<sub>3</sub> there are two main reasons for very different emissions compared to last year's submission: the new emission factors for housing systems (**recalculation No. 3**) results in significantly lower emissions for cattle housing systems and slightly lower emissions for pig housing systems. The correction of the numbers of horses (**recalculation No. 4**) more than doubles the emissions of the other animals. Many of the other recalculations have much smaller effects, see main page of the agricultural sector). Overall the opposing changes partially cancel each other out and result in slightly higher emissions up to 2014 and slightly lower emissions thereafter compared with last year's submission.

The total emissions of NO<sub>x</sub> for all years are much higher than those of submission 2024. The main reason for this is the doubling of the N<sub>2</sub>O emission factors for solid storage systems in IPCC 2019, which results directly in a doubling of the NO<sub>x</sub> emission factor (**recalculation No. 6**). Further details on recalculations are described in Rösemann et al. (2025), Chapter 1.3.

Table 4: REC-1: Revised NH<sub>3</sub> emissions, in kilotonnes

		1990	1995	2000	2005	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	<b>NFR TOTAL EMISSIONS</b>														
Total	<b>current submission</b>	300.67	252.12	248.41	248.80	241.45	237.98	233.87	231.70	224.95	220.40	216.51	208.17	197.88	196.54
	<b>previous submission</b>	296.69	245.32	244.46	244.89	241.21	238.12	234.24	232.05	225.13	220.64	216.70	208.65	199.17	
	<b>absolute change</b>	3.99	6.79	3.95	3.91	0.24	-0.14	-0.37	-0.36	-0.19	-0.24	-0.19	-0.49	-1.29	
	<b>relative change [%]</b>	1.33	2.69	1.59	1.57	0.10	-0.06	-0.16	-0.15	-0.08	-0.11	-0.09	-0.23	-0.65	
dairy cattle	<b>current submission</b>	60.08	50.88	47.58	47.96	50.59	51.16	50.96	50.81	50.34	50.41	49.61	48.53	48.11	47.56
	<b>previous submission</b>	62.10	53.93	50.69	51.58	55.51	56.24	56.10	56.02	55.58	55.80	55.01	53.91	53.32	
other cattle	<b>current submission</b>	75.09	61.37	58.84	54.43	53.44	52.45	51.18	49.73	47.86	46.37	45.09	44.10	43.95	43.75
	<b>previous submission</b>	81.36	66.68	63.90	59.08	58.36	57.39	56.11	54.62	52.67	51.15	49.77	48.75	48.60	
swine	<b>current submission</b>	120.20	90.53	93.99	96.33	90.07	87.72	85.80	85.33	81.27	78.46	77.66	71.70	62.66	62.12
	<b>previous submission</b>	120.10	90.66	94.17	96.62	90.69	88.38	86.47	86.02	81.94	79.10	78.37	72.37	63.46	
poultry	<b>current submission</b>	23.31	22.67	26.16	28.07	28.26	27.82	27.37	27.17	26.72	26.32	25.23	24.50	23.43	22.93
	<b>previous submission</b>	22.93	22.33	25.83	27.77	28.42	28.01	27.57	27.36	26.90	26.53	25.48	25.53	25.66	
other animals	<b>current submission</b>	22.00	26.67	21.85	22.00	19.10	18.82	18.56	18.66	18.75	18.84	18.92	19.32	19.73	20.18
	<b>previous submission</b>	10.21	11.72	9.87	9.84	8.23	8.10	7.99	8.03	8.04	8.06	8.06	8.10	8.14	



Table 5: REC-2: Revised NO<sub>x</sub> emissions, in kilotonnes

		1990	1995	2000	2005	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
	<b>NFR TOTAL EMISSIONS</b>														
Totals	<b>current submission</b>	2.403	2.119	2.023	2.014	1.903	1.878	1.848	1.822	1.783	1.750	1.716	1.658	1.619	1.621
	<b>previous submission</b>	1.734	1.558	1.521	1.514	1.459	1.448	1.434	1.418	1.392	1.376	1.354	1.308	1.272	
	<b>absolute change</b>	0.67	0.56	0.50	0.50	0.44	0.43	0.41	0.40	0.39	0.37	0.36	0.35	0.35	
	<b>relative change [%]</b>	27.83	26.47	24.79	24.83	23.29	22.89	22.42	22.16	21.94	21.37	21.13	21.11	21.44	
dairy cattle	<b>current submission</b>	0.892	0.708	0.672	0.658	0.609	0.607	0.600	0.590	0.585	0.580	0.570	0.549	0.544	0.545
	<b>previous submission</b>	0.671	0.597	0.570	0.551	0.516	0.518	0.516	0.511	0.510	0.512	0.507	0.493	0.485	
other cattle	<b>current submission</b>	0.843	0.726	0.711	0.668	0.657	0.652	0.642	0.630	0.613	0.600	0.582	0.565	0.561	0.558
	<b>previous submission</b>	0.690	0.604	0.587	0.551	0.550	0.548	0.546	0.540	0.531	0.525	0.510	0.497	0.495	
swine	<b>current submission</b>	0.360	0.319	0.332	0.372	0.345	0.332	0.322	0.318	0.300	0.286	0.281	0.258	0.224	0.222
	<b>previous submission</b>	0.281	0.256	0.270	0.313	0.294	0.283	0.275	0.270	0.254	0.242	0.240	0.222	0.195	
poultry	<b>current submission</b>	0.026	0.025	0.029	0.034	0.048	0.048	0.047	0.047	0.046	0.044	0.042	0.040	0.040	0.039
	<b>previous submission</b>	0.026	0.025	0.028	0.034	0.046	0.046	0.046	0.046	0.045	0.045	0.044	0.043	0.044	
other animals	<b>current submission</b>	0.282	0.340	0.279	0.281	0.243	0.240	0.236	0.238	0.239	0.240	0.241	0.246	0.251	0.257
	<b>previous submission</b>	0.067	0.076	0.065	0.064	0.054	0.053	0.052	0.052	0.052	0.052	0.052	0.053	0.053	

**Planned improvements**

No improvements are planned at present.

**NMVOC**

In 2022, NMVOC emissions from manure management amount to 278.2 kt which is 96.9 % of total NMVOC emissions from the agricultural sector. 84.8 % originate from cattle, 15.2 % from other animals.

**Method**

The Tier 2 methodology provided by EMEP (2019)-3B-28 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 (2019)-3B-17) was used. The use of the Tier 2 methodology yields NMVOC emissions which formally could be reported in the sectors 3.D.a.2.a (application of manure to soils) and 3.D.a.3 (grazing emissions). However, to be congruent with the NMVOC emissions for other animal categories, Germany reports these emissions in the NMVOC emissions reported from manure management (3.B). For the NFR codes 3.D.a.2.a and 3.D.a.3 the key note IE is used for NMVOC emissions.

**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 2024, Chapter 5.1.3.3,
- proportion  $x_{\text{house}}$  of the year the animals spend in the livestock building: country specific data, being equal to  $1 - x_{\text{graz}}$  with  $x_{\text{graz}}$  the proportion of the year spent on pasture, see NIR 2024, Chapter 19.3.2,
- $\text{FRAC}_{\text{silage}}$ : 1 as proposed by EMEP (2019)-3B-29, since silage feeding for cattle is considered dominant in Germany
- $\text{FRAC}_{\text{silage store}}$ : 0.25 as proposed by EMEP (2019)-3B-30 for European conditions
- $\text{EF}_{\text{NMVOC, silage feeding}}$ ,  $\text{EF}_{\text{NMVOC, house}}$ ,  $\text{EF}_{\text{NMVOC, graz}}$  are taken from EMEP (2019)-3B-32, table 3.11 as 0.0002002, 0.0000353 and 0.0000069 kg NMVOC/MJ feed intake, respectively,
- $\text{EF}_{\text{NH}_3, \text{storage}}$ ,  $\text{EF}_{\text{NH}_3, \text{building}}$  and  $\text{EF}_{\text{NH}_3, \text{application}}$  are taken from the NH<sub>3</sub> reporting (see above and 3.D).



	1990	1995	2000	2005	2014	2015	2016	2017	2018	2019	2020	2021	2022
<b>current submission</b>	391.38	333.81	320.75	300.65	305.69	304.35	301.05	297.97	293.90	290.92	287.04	281.57	278.18
<b>previous submission</b>	390.91	332.32	318.01	296.90	305.49	304.13	300.85	297.81	293.76	290.79	286.92	281.15	
<b>absolute change</b>	0.47	1.49	2.74	3.75	0.21	0.22	0.19	0.17	0.14	0.14	0.12	0.41	
<b>relative change [%]</b>	0.12	0.45	0.86	1.26	0.07	0.07	0.06	0.06	0.05	0.05	0.04	0.15	
<b>thereof: from dairy cattle</b>													
<b>current submission</b>	196.60	170.95	161.94	154.86	162.75	163.45	162.41	161.42	160.76	160.36	158.93	155.86	153.87
<b>previous submission</b>	196.60	170.95	161.94	154.87	162.74	163.42	162.39	161.40	160.74	160.34	158.92	155.75	
<b>thereof: from other cattle</b>													
<b>current submission</b>	153.85	124.43	117.46	102.42	96.10	94.85	93.11	91.00	88.24	85.98	83.68	82.29	81.92
<b>previous submission</b>	153.85	124.43	117.46	102.42	96.04	94.78	93.05	90.94	88.18	85.93	83.62	82.03	
<b>thereof: from other animals</b>													
<b>current submission</b>	40.93	38.42	41.36	43.36	46.85	46.05	45.53	45.55	44.91	44.58	44.43	43.42	42.39
<b>previous submission</b>	40.46	36.94	38.62	39.61	46.70	45.93	45.42	45.47	44.85	44.52	44.38	43.37	

### Planned improvements

No improvements are planned at present.

## Particle emissions

In 2022, **TSP** emissions from manure management amount to 64.4 % of total emissions from the agricultural sector. Of these emissions 24.7 % originate from cattle, 32.0 % from pigs, and 42.6 % from poultry.

36.6 % of total **PM<sub>10</sub>** emissions from the agricultural sector are caused by manure management, where 35.7 % originate from cattle, 14.6 % from pigs, and 48.7 % from poultry.

68.6 % of total **PM<sub>2.5</sub>** emissions from the agricultural sector are caused by manure management, where 78.0 % originate from cattle, 2.3 % from pigs, and 18.0 % from poultry.

### Method

EMEP (2013-3B-26) provided a Tier 2 methodology. In the 2019 Guidebook (EMEP, 2019), this methodology has been replaced by a Tier 1 methodology. However, EF for cattle derived with the EMEP 2013 Tier 2 methodology remained unchanged. Therefore, the EMEP 2013<sup>9)</sup> methodology was kept for cattle. For swine the EMEP 2013 methodology was formally kept but the EMEP 2019 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 2019 EFs are simply rounded EMEP 2013 EFs, the unrounded EMEP 2013 EFs were kept. For rabbits the EFs from The Netherlands' inventory were adopted (Huis In't Veld et al, 2011)<sup>10)</sup>, for ostriches the EFs of goats were used. 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<sub>10</sub>, 70 % for PM<sub>2.5</sub>). For details see Vos et al. (2024), Chapter 4.2.2.

### Activity data

Animal numbers serve as activity data, see Table 1.

### Emission factors

Tier 1 emission factors for TSP, PM<sub>10</sub> and PM<sub>2.5</sub> from livestock husbandry are provided in EMEP (2019-3B-19), Table 3.5 and 55, Table A1.7. For cattle the Tier 2 emission factors provided in EMEP (2013-3B-29), Table 3-11 were used, because they differentiate between slurry and solid manure systems and were also used to develop the EMEP 2019 Tier 1 emissions factors.

Table 8: IEF for TSP, PM<sub>10</sub> & PM<sub>2.5</sub> from manure management

[illegible]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
<b>ostrich</b>	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034
<b>fur animals</b>	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040

## 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 for the earlier years of the time series. However, due to increases in places equipped with air scrubbing and 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 (0.67). For laying hens ( $R^2 = 0.98$ ) and broilers ( $R^2 = 0.99$ ), due to the low prevalence of air scrubbing systems TSP emissions almost perfectly correlate with the animal numbers provided in Table 1.

## Recalculations

The following table shows the effects of recalculations on emissions of particulate matter. Visible differences occur especially in the years before 2013, these are due to the correction of the numbers of laying hens and broilers (**recalculation No. 6**). The addition of new animal categories to the inventory (**recalculation No. 1**) shows only a very small effect. See [main page of the agricultural sector](#). Further details on recalculations are described in Vos et al. (2024), Chapter 1.3.

Table 9: REC-4: Revised particle emissions (TSP, PM<sub>10</sub> & PM<sub>2.5</sub>), in kilotonnes

	1990	1995	2000	2005	2014	2015	2016	2017	2018	2019	2020	2021	2022
<b>TOTAL SUSPENDED PARTICLES (TSP)</b>													
<b>current submission</b>	50.06	42.92	43.82	43.05	44.49	43.63	43.28	43.25	42.22	41.52	41.37	39.59	38.05
<b>previous submission</b>	50.03	42.23	42.39	41.09	44.48	43.62	43.28	43.26	42.22	41.51	41.37	39.59	
<b>absolute change</b>	0.02	0.69	1.44	1.96	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.01	
<b>relative change [%]</b>	0.05	1.65	3.39	4.77	0.02	0.02	0.01	-0.01	-0.01	0.02	-0.01	0.01	
<b>PM<sub>10</sub></b>													
<b>current submission</b>	14.36	12.94	13.11	12.94	13.69	13.48	13.30	13.24	12.99	12.80	12.66	12.34	12.12
<b>previous submission</b>	14.33	12.71	12.62	12.25	13.68	13.47	13.29	13.24	12.99	12.79	12.65	12.34	
<b>absolute change</b>	0.02	0.23	0.48	0.69	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.01	
<b>relative change [%]</b>	0.15	1.82	3.83	5.62	0.06	0.06	0.05	0.04	0.04	0.05	0.04	0.04	
<b>PM<sub>2.5</sub></b>													
<b>current submission</b>	5.02	4.50	4.22	3.95	4.05	4.02	3.97	3.94	3.87	3.79	3.71	3.64	3.62
<b>previous submission</b>	5.01	4.47	4.18	3.88	4.05	4.02	3.97	3.94	3.86	3.79	3.71	3.64	
<b>absolute change</b>	0.00	0.02	0.05	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
<b>relative change [%]</b>	0.09	0.52	1.10	1.67	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	



For **pollutant-specific information on recalculated emission estimates for Base Year and 2021**, please see the pollutant specific recalculation tables following [chapter 8.1 - Recalculations](#).

## Planned improvements

No improvements are planned at present.

## Uncertainty

Details will be described in [chapter 1.7](#).

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