3.D - Agricultural Soils

Short description

NFR-Code	Name of Category	Method	AD	EF
3.D	**Agricultural Soils**			
consisting of / including source categories				
3.D.a.1	Inorganic N-fertilizers (includes also urea application)	T2 (NH_3), T1 (NO_x)	NS, RS	D (NH_3), D (NO_x)
3.D.a.2.a	Animal manure applied to soils	T2, T3 (NH_3), T1 (NO_x)	M	CS (NH_3), D (NO_x)
3.D.a.2.b	Sewage sludge applied to soils	T1 (NH_3, NO_x)	NS, RS	D (NH_3), D (NO_x)
3.D.a.2.c	Other organic fertilisers applied to soils (including compost)	T2 (NO_x, NH_3)	M	CS
3.D.a.3	Urine and dung deposited by grazing animals	T1 (NH_3, NO_x)	NS, RS	D
3.D.a.4	Crop residues applied to soil	T2 (NH_3)	NS, RS	D
3.D.c	Farm-level agricultural operations including storage, handling and transport of agricultural products	T2 (TSP, PM_{10}, $PM_{2.5}$)	NS, RS	D
3.D.d	Off-farm storage, handling and transport of bulk agricultural products	NA & NR (Black Carbon only)		
3.D.e	Cultivated crops	T2 (NMVOC)	NS, RS	D
3.D.f	Use of pesticides	T2 (HCB)	NS	D

	NO_x	**NMVOC**	SO_2	**NH_3**	**$PM_{2.5}$**	**PM_{10}**	**TSP**	BC	CO	Heavy Metals	PAHs	**HCB**	PCBs
3.D.a.1	**L/T**	NA	NA	**L/T**	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.a.2.a	**L/-**	IE	NA	**L/T**	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.a.2.b	-/-	NA	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.a.2.c	-/-	NA	NA	**L/T**	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.a.3	-/-	IE	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.a.4	NA	NA	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.c	NA	NA	NA	NA	**L/-**	**L/-**	**L/-**	NA	NA	NA	NA	NA	NA
3.D.e	NA	-/-	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3.D.f	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**L/-**	NA

Method(s) applied	
D	Default
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/EEA Emission Inventory Guidebook - 2019, in category chapters.	
(source for) Activity Data	
NS	National Statistics
RS	Regional Statistics
IS	International Statistics
PS	Plant Specific
As	Associations, business organisations
Q	specific Questionnaires (or surveys)
M	Model / Modelled
C	Confidential
(source for) Emission Factors	
D	Default (EMEP Guidebook)
CS	Country Specific

PS	Plant Specific
M	Model / Modelled
C	Confidential

Country specifics

NH_3 and NO_x

In 2023, agricultural soils emitted 328.7 kt NH_3 or 62.4 % of the total agricultural NH_3 emissions in Germany (527.0 kt NH_3). The main contributions to the total NH_3 emissions from agricultural soils are the application of manure (3.D.a.2.a), with 185.0 kt (56.3 %), the application of synthetic N-fertilizers (3.D.a.1) with 61.8 kt (18.8 %), and the application of other organic N-fertilizers (3.D.a.2.c) with 58.4 kt (17.8 %).

N excretions on pastures (3.D.a.3) have a share of 15.1 kt NH_3 (4.6 %), emissions from crop residues (3.D.a.4) are 6.9kt NH_3 (2.1 %), and the application of sewage sludge (3.D.a.2.b) 1.6 kt NH_3 (0.5 %).

In 2023, agricultural soils were the source of 98.3 % (97.8 kt) of the total of NO_x emissions in the agricultural category (99.5 kt). The NO_x emissions from agricultural soils are primarily due to application of inorganic fertilizer (3.D.a.1) (40.9 kt) and manure (3.D.a.2.a) (36.7 kt) Application of other organic N-fertilizers (3.D.a.2.c) contributes 14.6 kt, 5.2 kt are due to excretions on pastures (3.D.a.3). Emissions from application of sewage sludge (3.D.a.2.b) contribute 0.5 kt.

NMVOC

In 2023, the category of agricultural soils contributed 9.2 kt NMVOC or 3.1 % to the total agricultural NMVOC emissions in Germany (301.3 kt NMVOC). The only emission source was cultivated crops (3.D.e).

TSP, PM_{10} & $PM_{2.5}$

In 2023, agricultural soils contributed, respectively, 38.8 % (23.7 kt), 67.0 % (23.7 kt) and 33.7 % (1.8 kt) to the total agricultural TSP, PM_{10} and $PM_{2.5}$ emissions (61.0 kt, 35.4 kt, 5.4 kt, respectively). The emissions are reported in category 3.D.c (Farm-level agricultural operations including storage, handling and transport of agricultural products).

3.D.a.1 - Inorganic N-fertilizers

The calculation of NH_3 and NO_x (NO) emissions from the application of synthetic fertilizers is described in Vos et al. (2024), Chapters 5.2.1.2 and 5.2.2.2 1)[1].

Activity Data

German statistics report the amounts of fertilizers sold which are assumed to equal the amounts that are applied. Since the 2021 submission, storage effects are approximated by applying a moving average to the sales data (moving centered three-year average, for the last year a weighted two-year average, which assigns 2/3 of the weight to the last year). Since the year 2022, data for the sales of urea that is stabilized with urease inhibitor is available. It cannot be published because of data-privacy issues. Therefore, the emissions are calculated and provided by the federal statistical office using the emission factors as described below. The activity data are published in aggregate for urea, urea+inhibitor and nitrogen solutions to maintain confidentiality. For details see Rösemann et al. (2025), Chapter 2.8.

Table 1: AD for the estimation of NH_3 and NO_x emissions from application of synthetic fertilizers

Application of inorganic fertilizers in [Gg N]														
	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Application of fertilizers (total)	2,195	1,723	1,922	1,797	1,635	1,736	1,731	1,622	1,499	1,404	1,327	1,245	1,123	1,037
calcium ammonium nitrate	1,368	1,044	982	824	689	618	605	571	543	520	497	470	422	385
urea and ammonia nitrate urea solutions (AHL)	369	403	508	526	542	590	604	539	460	385	342	318	293	282
ammonium phosphates	85	55	66	55	64	84	82	77	65	64	58	51	41	35
other NK and NPK	246	162	175	126	63	67	62	54	52	51	51	47	40	35
other straight fertilizers	127	60	191	266	277	377	377	381	378	383	379	359	328	300

Methodology

NH_3 emissions from the application of synthetic fertilizers are calculated using the Tier 2 approach according to EMEP (2023)-3D-16ff [1], distinguishing between various fertilizer types, see Table 2. For NO_x, the Tier 1 approach described in EMEP (2023) [10]-3D-15 is applied.

Emission factors

The emission factors for NH_3 depend on fertilizer type, see EMEP (2023)-3D-17. Table 2 lists the EMEP emission factors for the fertilizers used in the inventory. In order to reflect average German conditions, the emission factors for cool climate and a pH value lower than 7 was chosen. For urea fertilizer the German fertilizer ordinance prescribes the use of urease inhibitors or the immediate incorporation into the soil from 2020 onwards. The NH_3 emission factor for urea fertilizers is therefore reduced by 70% from 2020 onwards for the immediate incorporation of urea, according to Bittman et al. (2014, Table 15)[2]. For the use of urease inhibitors the emission factor for urea fertilizer is reduced by 60%. For details see Rösemann et al. (2025)[3], Chapter 5.2.1.2.

Table 2: Synthetic fertilizers, emission factors in kg NH_3 per kg fertilizer N

Fertilizer type	**EF**
calcium ammonium nitrate	0.024
ammonia nitrate urea solutions (AHL)	0.087
urea (up to 2019)	0.195
urea (from 2020 with urease inhibitor)	0.078
urea (from 2020 if incorporated)	0.0585
ammonium phosphates	0.084
other NK and NPK	0.084
other straight fertilizers	0.084

For NO_x, the simpler methodology by EMEP (2023)-3D-13 was used. The emission factor 0.040 from EMEP, 2023-3D, Table 3.1 has the unit of [kg N_2O per kg fertilizer N] and was derived from [4].

The German inventory uses the emission factor 0.012 kg NO-N per kg N derived from Stehfest and Bouwman (2006) directly. This is equivalent to an emission factor of 0.03943 kg NO_x per kg fertilizer N (obtained by multiplying 0.012 kg NO-N per kg N with the molar weight ratio 46/14 for NO_2: NO). The inventory uses the unrounded emission factor.

Table 3: Emission factor for NO_x emissions from fertilizer application

Emission factor	kg NO-N per kg fertilizer N	kg NO_x per kg fertilizer N
EF_{fert}	0.012	0.039

Trend discussion for Key Sources

Since 2016, fertilizer sales have fallen dramatically (by around a third). Emissions have fallen accordingly. This is even more pronounced for NH_3 than for NO_x, as total NH_3 from the application of mineral fertilizers is, until the year 2019, very strongly correlated with the amount of urea applied (R^2 = 0.72), the sales of which have decreased more than for all other mineral fertilizers. Since 2020 the negative trend is reinforced as urea fertilizer have to be either used with urease inhibitors or have to be incorporated into the soil directly, which reduces emissions.

Recalculations

Table REC-1 shows the effects of recalculations on NH_3 and NO_x emissions. The enormous differences for NH_3 emissions are due to the use of the new EMEP (2023)[5)] emission factors (**recalculation No. 1**). Concerning NO_x, emissions differences only occur in 2022, resulting from applying the moving average to sales data (see activity data).

Table 4: REC-1: Revised NH_3 and NO_x emissions, in kilotonnes

	Submission	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022	2023
Ammonia	current	129.55	102.80	130.65	134.39	136.77	155.61	157.68	144.31	128.19	114.66	77.56	73.59	67.18	61.79
	previous	78.71	69.55	85.64	86.36	88.43	97.89	99.73	89.25	76.79	65.63	36.64	35.02	33.44	
	absolute change	50.83	33.25	45.01	48.03	48.34	57.73	57.95	55.06	51.40	49.03	40.92	38.57	33.73	
	relative change [%]	64.58	47.80	52.56	55.62	54.66	58.97	58.10	61.69	66.94	74.71	111.70	110.13	100.87	
Nitrogen oxides	current	86.53	67.93	75.77	70.84	64.48	68.46	68.24	63.95	59.11	55.34	52.31	49.08	44.29	40.89
	previous	86.53	67.93	75.77	70.84	64.48	68.46	68.24	63.95	59.11	55.34	52.31	49.08	45.46	
	absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-1.18	
	relative change [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-2.59	

Planned improvements

No improvements are planned at present.

3.D.a.2.a - Animal manure applied to soils

In this sub-category Germany reports the NH_3 and NO_x (NO) emissions from application of manure (including application of anaerobically digested manure). An overview is given in Rösemann et al. (2025)[6)], Chapters 5.2.1.2 and 5.2.2.2. Germany uses the Tier 2 methodology for estimating NMVOC emissions for cattle in sector 3.B (manure management). The use of this methodology yields NMVOC emissions which formally could be reported in the sectors 3.D.a.2.a 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 notation key IE is used for NMVOC emissions.

Activity data

The calculation of the amount of N in manure applied is based on the N mass flow approach (see 3.B). It is the total of N excreted by animals in the housing and the N imported with bedding material minus N losses by emissions of N species from housing and storage. Hence, the amount of total N includes the N contained in anaerobically digested manures to be applied to the field.

The frequencies of application techniques and incorporation times as well as the underlying data sources are described in Rösemann et al. (2025) [7], Chapter 2.5. The frequencies are provided. in the NID 2025[8], Chapter 17.3.1.

Table 5: AD for the estimation of NH_3 and NO_x emissions from application of manure

Application of manure in [kt N]												
1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
1,131	987	970	940	945	984	978	974	959	952	943	919	893

Methodology

NH_3 emissions from manure application are calculated separately for each animal species in the mass flow approach by multiplying the respective TAN amount with NH_3 emission factors for the various manure application techniques. For details see [3-b-manure-management 3.B] and Rösemann et al. (2025)[9], Chapter 5.2.1.2. For NO_x emissions from manure application the inventory calculates NO-N emissions (see Rösemann et al. (2025) [10], Chapter 5.2.2.2, that are subsequently converted into NO_x emissions by multiplying with the molar weight ratio 46/14. The Tier 1 approach for the application of synthetic fertilizer as described in EMEP (2023)-3D-13 is used.

Emission factors

The following table shows the time series of the overall German NH_3 IEF defined as the ratio of total NH_3-N emission from manure application to the total amount of N spread with manure.

Table 6: IEF for NH_3–N from application of manure

IEF in [kg NH3-N per kg N in applied manure]												
1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
0.208	0.194	0.187	0.175	0.169	0.161	0.159	0.157	0.155	0.153	0.150	0.151	0.153

Trend discussion for Key Sources

Both NH_3 and NO_x emissions from the application of animal manures are key sources. Total NO_x is calculated proportionally to the total N in the manures applied which decreased remarkably from 1990 to 1991 due to the decline in animal numbers following the German reunification (reduction of livestock numbers in Eastern Germany). In the 1990s and 2000s this was followed by a weakened decline in animal manure amounts. From 2010 to 2014 there was a slight increase and since then the amount of N in manure applied has been declining again, see Table 6. The NO_x emissions follow these trends. For total NH_3 emissions there is a negative trend. This is due to the decreasing amounts of animal manures and the increasing use of application practices with lower NH_3 emission factors.

Recalculations

For all years, the total emissions of NH_3 and NO_x from application of manure are slightly higher than those of last year's submission.

These differences are predominantly caused by a higher estimate of manure N, which is applied, compared to the last submission. Many of the recalculations have an effect on this. The two most important ones are **No. 3** (lower NH_3 emission factors for cattle and pig housing result in more N available for spreading) and **No. 4** (correction of horse numbers by a factor of 2.75), both of which increase emissions see main page of the agricultural sector, list of recalculation reasons. Further details on recalculations are described in Rösemann et al. (2025) [11], Chapter 1.3.

Table 7: REC-2: Revised NH_3 and NO_x emissions, in kilotonnes

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
Ammonia													
current submission	286.21	232.97	220.16	199.38	193.95	191.94	188.84	185.61	180.61	176.70	171.37	168.12	165.79
previous submission	285.58	231.79	218.55	197.69	191.85	191.19	188.04	184.84	179.85	176.00	170.65	167.43	
absolute change	0.63	1.18	1.60	1.69	2.09	0.75	0.80	0.76	0.76	0.70	0.72	0.69	
relative change [%]	0.22	0.51	0.73	0.86	1.09	0.39	0.43	0.41	0.42	0.40	0.42	0.41	

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
Nitrogen oxides													
current submission	44.59	38.90	38.23	37.05	37.25	38.81	38.57	38.39	37.83	37.52	37.19	36.22	35.22
previous submission	44.52	38.77	38.04	36.84	37.00	38.80	38.56	38.39	37.82	37.51	37.16	36.15	
absolute change	0.07	0.13	0.19	0.21	0.25	0.01	0.01	0.01	0.01	0.01	0.02	0.07	
relative change [%]	0.15	0.34	0.49	0.57	0.69	0.02	0.02	0.01	0.03	0.03	0.06	0.20	

Planned improvements

No improvements are planned at present.

3.D.a.2.b – Sewage sludge applied to soils

The calculation of NH_3 and NO_x (NO) emissions from application of sewage sludge is described in Rösemann et al. (2025) [12], Chapters 5.2.1.2 and 5.2.2.2.

Activity data

N quantities from application of sewage sludge were calculated from data of the German Environment Agency and (since 2009) from data of the Federal Statistical Office.

Table 8: AD for the estimation of NH_3 and NO_x emissions from application of sewage sludge

Application of sewage sludge in [kt N]												
1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
27	35	33	27	26	19	19	14	13	16	14	12	12

Methodology

A Tier 1 methodology is used (EMEP, 2023, 3D, Chapter 3.3.1). NH_3 and NO_x emissions are calculated by multiplying the amounts of N in sewage sludge applied with the respective emission factors.

Emission factors

EMEP (2023)-3.D, Table 3-1 provides a Tier 1 emission factor for NH_3 (0.13 kg NH_3 per kg N applied) emissions from application of sewage sludge. The German inventory uses the equivalent emission factor in NH_3-N units which is 0.11 kg NH_3-N per kg N applied (cf. the derivation of the emission factor described in the appendix of EMEP (2023)-3D, page 35). For NO_x the same emission factor like for the application of synthetic fertilizer was used (see Table 3).

Trend discussion for Key Sources

NH_3 and NO_x emissions from the application of sewage sludge are no key sources.

Recalculations

There were no recalculations concerning sewage sludge except the replacement of extrapolated activity data in 2022 with data from the Federal Statistical Office. Further details on recalculations are described in Rösemann et al. (2025), Chapter 1.3.

Table 9: Revised NH_3 and NO_x emissions, in kilotonnes

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
Ammonia													

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
current submission	3.66	4.71	4.40	3.66	3.51	2.52	2.51	1.87	1.78	2.14	1.85	1.61	1.61
previous submission	3.66	4.71	4.40	3.66	3.48	2.50	2.50	1.89	1.67	1.90	1.67	1.67	
absolute change	0.00	0.00	0.00	0.00	0.03	0.02	0.02	-0.02	0.11	0.24	0.18	-0.06	
relative change [%]	0.00	0.00	0.00	0.00	0.93	0.64	0.66	-1.22	6.51	12.61	10.90	-3.85	
Nitrogen oxides													
current submission	1.08	1.39	1.30	1.08	1.04	0.74	0.74	0.55	0.52	0.63	0.55	0.47	0.47
previous submission	1.08	1.39	1.30	1.08	1.03	0.74	0.74	0.56	0.49	0.56	0.49	0.49	
absolute change	0.00	0.00	0.00	0.00	0.01	0.00	0.00	-0.01	0.03	0.07	0.05	-0.02	
relative change [%]	0.00	0.00	0.00	0.00	0.93	0.64	0.66	-1.22	6.51	12.61	10.90	-3.85	

Planned improvements

No improvements are planned at present.

3.D.a.2.c - Other organic fertilizers applied to soils

This sub category contains the total of Germany's NH_3 and NO_x (NO) emissions from application of - residues from digested energy crops, - residues from digested waste, - compost from biowaste, - compost from green waste, and - imported animal manures. For details see Rösemann et al. (2025), Chapters 5.2.1.2 and 5.2.2.2.

Activity data

Activity data is the amount of N in residues from anaerobic digestion of energy crops and waste and of compost from biowaste and green waste when leaving storage, as well as the amount of N in imported animal manures. For energy crops this is the N contained in the energy crops when being fed into the digestion process minus the N losses by emissions of N species from the storage of the residues (see 3.I). N losses from pre-storage are negligible and there are no N losses from fermenter (see Rösemann et al. (2025), Chapter 5.1). For residues from digested waste, compost from biowaste and compost from green waste the amount of N was derived from the waste statistics of the Federal Statistical Office (see Rösemann et al. (2025), Chapter 2.8). For imported manure the amounts of N were derived from statistics published by CBS (Statistics Netherlands) and RVO (Rijksdienst voor Ondernemend Nederland) The imported manure is categorized into cattle slurry, pig slurry, poultry manure, horse manure and mixed solid manure. Only imported manures from The Netherlands are taken into account, as for other countries the amounts of imported manures are unknown as are the amounts of exported manure. For details see Rösemann et al. (2025), Chapter 2.8.

Table 10: AD for the estimation of NH_3 and NO_x emissions emissions from application of other organic fertilizers

	Application of other organic fertilizers in kt N												
	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Residues, digested energy crops	0.05	0.59	5.12	43.36	158.69	288.92	287.59	283.07	279.15	279.38	285.56	280.37	280.37
Residues, digested waste	0.00	0.00	1.55	4.97	10.46	15.05	13.97	13.79	14.00	13.75	13.40	15.13	15.98
Compost, biowaste	4.51	19.54	31.87	28.82	22.64	22.59	23.34	21.90	25.14	24.31	25.42	22.98	24.57
Compost, greenwaste	1.13	4.90	7.67	9.46	11.27	13.67	14.29	14.87	14.92	15.89	16.74	15.95	17.58
Imported manure	5.19	19.26	15.56	21.48	27.41	27.53	30.26	26.95	21.22	19.91	16.96	14.22	14.61
TOTAL	**10.87**	**44.30**	**61.77**	**108.09**	**230.47**	**367.77**	**369.45**	**360.58**	**354.42**	**353.25**	**358.09**	**348.65**	**353.12**

Methodology

The NH_3 emissions are calculated the same way as the NH_3 emissions from application of animal manure (3.D.a.2.a). The frequencies of application techniques and incorporation times as well as the underlying data sources are provided e. g. in the NID 2025, Chapter 17.3.1. It is assumed that residues of digested waste are applied in the same way and have the same emission factors as residues from digested energy crops. For compost from biowaste and green waste it is assumed that they are applied in the same way and have the same emission factors as cattle solid manure. The amounts of TAN in the residues from digested energy crops applied are obtained from the calculations of emissions from the storage of the digested energy crops (3.I). The amounts of TAN in the residues from digested waste, compost from biowaste and compost from green waste are derived from industry data (provided by Bundesgütegemeinschaft Kompost, BGK). For the imported manures it is assumed that the different imported manure types (see above) were applied in the same way as the corresponding domestic animal manure types. Mixed manure was treated like solid manure from goats, sheep and horses. Corresponding TAN contents were derived from publications of the German federal states. As published TAN contents vary strongly, for each imported manure type the maximum of published TAN contents was assumed to prevent an underestimation of the NH_3 emissions. For details see Rösemann et al. (2025), Chapter 2.8.

For NO_x emissions the Tier 1 approach for the application of synthetic fertilizer as described in EMEP (2023)-3D-13 is used. The inventory calculates NO emissions that are subsequently converted into NO_x emissions by multiplying with the molar weight ratio 46/30.

Emission factors

For NH_3 the emission factors for untreated cattle slurry were adopted for residues from digested energy crops and residues from waste. The emission factors for cattle solid manure were adopted for compost from biowaste and compost from green waste, see Rösemann et al. (2025), Chapters 5.2.1.2 and 5.2.2.2. For imported manures the corresponding emission factors of the same type of domestic manure were used.

As the NO_x method for fertilizer application is used for the calculation of NO_x emissions from the application of residues, the emission factor for fertilizer application was used (see Table 3).

Table 11: IEF for NH_3-N emissions from application of other organic fertilizers

	IEF in kg NH3-N per kg N of other organic fertilizers												
	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Residues, digested energy crops	0.182	0.182	0.183	0.183	0.183	0.153	0.150	0.147	0.144	0.141	0.139	0.138	0.138
Residues, digested waste	0.000	0.000	0.192	0.193	0.193	0.171	0.164	0.156	0.163	0.162	0.163	0.162	0.160
Compost, biowaste	0.038	0.038	0.038	0.036	0.034	0.032	0.032	0.032	0.029	0.033	0.034	0.036	0.037
Compost, greenwaste	0.014	0.014	0.014	0.014	0.013	0.015	0.015	0.020	0.013	0.012	0.012	0.012	0.013
Imported manure	0.209	0.204	0.202	0.185	0.174	0.153	0.148	0.147	0.148	0.148	0.144	0.145	0.146
TOTAL	**0.118**	**0.110**	**0.092**	**0.130**	**0.160**	**0.141**	**0.138**	**0.135**	**0.131**	**0.129**	**0.127**	**0.127**	**0.126**

Trend discussion for Key Sources

The application of other organic fertilizers is a key source for NH_3. Emissions are dominated by the emissions from digested energy crops. They have become important since about 2005 and have risen sharply until 2013. Since then, they have changed little each year and tend to decrease slightly in the last few years. The latter is mostly due to the increasing use of application practices with lower NH_3 emission factors.

Recalculations

Recalculations after 2013 are mainly due to the update of activity data. Concerning NH_3 emissions, small differences occur in all years. This is because the underlying spatial distribution of imported manure is different, which results in different IEFs compared to last year's submission. Another reason is the interpolation of RAUMIS distribution data before 1999 (see main page of the agricultural sector, list of recalculation **reasons, 19, 20 and 21**, and Rösemann et al. (2025), Chapter 1.3).

Table 12:REC-4: Revised NH_3 and NO_x emissions from application of other organic fertilizers, in kilotonnes

	1990	**1995**	**2000**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Ammonia													
current submission	1.55	5.89	6.90	62.15	63.06	63.03	61.69	59.17	56.51	55.28	55.04	53.83	54.21
previous submission	0.24	1.12	3.15	60.14	60.84	60.66	58.87	56.82	55.02	53.96	54.33	54.31	
absolute change	1.32	4.78	3.75	2.01	2.22	2.37	2.82	2.35	1.49	1.31	0.71	-0.48	
relative change [%]	558.94	427.65	118.87	3.34	3.65	3.91	4.80	4.13	2.71	2.43	1.31	-0.89	
Nitrogen oxides													
current submission	0.43	1.75	2.44	13.15	13.99	14.50	14.57	14.22	13.97	13.93	14.12	13.75	13.92

	1990	1995	2000	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
previous submission	0.22	0.99	1.83	12.76	13.53	14.00	13.95	13.71	13.68	13.68	14.00	13.99	
absolute change	0.20	0.76	0.60	0.40	0.45	0.50	0.62	0.51	0.30	0.24	0.12	-0.24	
relative change [%]	91.19	76.71	32.86	3.12	3.35	3.56	4.43	3.69	2.17	1.79	0.88	-1.72	

Planned improvements

No improvements are planned at present.

3.D.a.3 - Urine and dung deposited by grazing animals

The calculation of NH_3 and NO_x (NO) emissions from N excretions on pasture is described in Rösemann et al. (2025), Chapters 5.2.1.1 and 5.2.2.1.

Activity data

Activity data for NH_3 emissions during grazing is the amount of TAN excreted on pasture, while for NO_x emissions it is the amount of N excreted.

The TAN excretions are derived by multiplying the share of N excretion on pastures with the N excretions and TAN contents provided in 3.B, Table 2.

Table 13: Shares of N excretions on pasture, in [%]

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
Dairy cows	20.3	15.6	12.7	11.4	10.0	8.6	8.3	8.0	7.6	7.4	7.4	7.4	7.4
Other cattle	15.1	17.3	18.9	19.0	19.6	20.5	20.7	20.9	21.2	21.4	21.5	21.4	21.4
Sheep	55.1	55.5	55.1	55.4	54.8	55.4	55.4	55.4	55.6	55.5	55.4	55.5	55.8
Goats	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2
Horses	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
Laying hens	0.1	0.1	0.5	1.0	1.7	2.3	2.4	2.3	2.5	2.6	2.8	2.8	3.0
Deer	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Ostrich	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0

Methodology

NH_3 emissions from grazing are calculated by multiplying the respective animal population (3.B, Table 1) with corresponding N excretions and relative TAN contents (3.B, Table 2) and the fraction of N excreted on pasture (Table 13). The result is multiplied with the animal specific emission factor (Table 14). NO emissions are calculated the same way with the exception that the emission factor is related to N excreted instead of TAN.

Emission Factors

The emission factors for NH_3 are taken from EMEP (2023)-3B-29, Table 3.9. They relate to the amount of TAN excreted on pasture. For laying hens, deer and ostriches there are no emission factors given in this table. Germany uses for laying hens an emission factor of 0.35 kg NH_3-N per kg TAN excreted, based on an expert judgement from KTBL (see Rösemann et al. 2025, Chapter 5.2.1.1). The same EF is used by UK. It was also used for ostriches. For deer the emission factor of sheep was adopted.

Following the intention of EMEP, 2023-3D, Table 3.1, the inventory uses for NO_x the same emission factor as for the application of synthetic fertilizer (see Table 3). In order to obtain NO_x emissions (as NO_2) the NO-N emission factor of 0.12 kg NO-N per kg N excreted is multiplied by 46/14.

Table 14: Emission factors for emissions of NH_3 and NO from grazing

Dairy cows	0.14 kg NH3-N per kg TAN excreted

Other cattle	0.14 kg NH3-N per kg TAN excreted
Horses	0.35 kg NH3-N per kg TAN excreted
Sheep, goats	0.09 kg NH3-N per kg TAN excreted
Laying hens	0.35 kg NH3-N per kg TAN excreted
Deer	0.09 kg NH3-N per kg TAN excreted
Ostriches	0.35 kg NH3-N per kg TAN excreted
All animals	0.012 kg NO-N per kg N excreted

Trend discussion for Key Sources

Emissions from urine and dung deposited by grazing animals are no key sources.

Recalculations

For all years, totals of NH_3 and NO_x emissions from grazing are slightly higher than those of last year's submission.

The main reason for that is the correction of the horse animal numbers by a factor of 2.75 (see main page of the agricultural sector, list of recalculations, **No. 4)**. Further details on recalculations are described in Rösemann et al. (2025), Chapter 1.3.

Table 15: REC-5: Revised NH_3 and NO_x emissions, in kilotonnes

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
Ammonia													
current submission	22.37	18.35	16.55	14.73	14.19	13.94	13.76	13.57	13.33	13.17	12.96	12.75	12.78
previous submission	22.24	18.17	16.32	14.48	13.91	13.67	13.48	13.29	13.05	12.89	12.68	12.47	
absolute change	0.14	0.18	0.23	0.25	0.28	0.27	0.27	0.27	0.28	0.28	0.28	0.29	
relative change [%]	0.61	1.01	1.43	1.73	2.02	1.99	2.01	2.05	2.11	2.14	2.21	2.30	
Nitrogen oxides													
current submission	8.50	6.95	6.31	5.64	5.40	5.24	5.17	5.09	4.99	4.93	4.86	4.78	4.78
previous submission	8.40	6.82	6.15	5.48	5.22	5.06	4.98	4.91	4.81	4.74	4.67	4.59	
absolute change	0.10	0.13	0.16	0.17	0.18	0.18	0.18	0.18	0.18	0.18	0.19	0.19	
relative change [%]	1.17	1.90	2.62	3.06	3.38	3.56	3.63	3.71	3.82	3.89	3.98	4.15	

Planned improvements

No improvements are planned at present.

3.D.a.4 - Crop residues applied to soil

The calculation of NH_3 from crop residues is described in Rösemann et al. (2025), Chapter 5.2.1.3. According to EMEP (2023) NH_3 emissions are only occurring in a significant amount from crop residues on the soil surface, which are present more than three days and have an N content of more than 0.0132 kg N per kg dry matter. This means that there are no NH_3 emissions from most crop residues of the most commonly used crops in Germany. The major source of the emissions are residues of grassland cuts.

Activity data

The NH_3 emissions are calculated proportionally to the amounts of N stored in the above-ground biomass, according to EMEP (2023).This requires the knowledge of the areas of cultivation, of crop yields and of the N contents of the above ground crop residues.

Table 16: AD for the estimation of NH_3 emissions from crop residues

test	

Methodology

According to EMEP (2023) the NH_3 emissions from crop residues can be neglected when the crop residues are on the field for less than three days. Thus the first step in the emission calculation is determining which share of the crop residues of each crop are incorporated into the soil or removed in the first three days after harvesting the crop. The remaining amounts are multiplied with their respective N contents and the resulting amounts of N are then multiplied with the NH_3-emission factor.

Emission factors

According to the methodology given in EMEP (2023) the emission factor for the NH_3 emissions from crop residues applied to the soil is zero if the N content of the above ground crop residues is below or equal to the threshold of 0.0132 kg N per kg dry matter. In all other cases the NH_3 emission factor is determined using the following linear regression, **Formel** see EMEP (2023):EF_NH_(3_x)=(410×N_(above dm_x)-5.42)÷100 **Formel** Where x is the according crop and N_{above} dm is the N content of the above ground dry matter. The implied emission factors provided in the following table are defined as ratio of the total NH_3-N emissions from crop residues to the total N in aboveground crop residues.

Table 17: IEF for NH_3-N emissions from crop residues

test

Trend discussion for Key Sources

NH_3 emissions from crop residues are no key source.

Recalculations

There are no recalculations because this source is reported the first time. _Table 18: REC-6: Revised NH_3 emissions, in kilotonnes_

test

Planned improvements

No improvements are planned at present.

3.D.c - Farm-level agricultural operations including storage, handling and transport of agricultural products

In this category Germany reports TSP, PM_{10} and $PM_{2.5}$ emissions from crop production according to EMEP (2023)-3D-22. For details see Rösemann et al. (2025), Chapter 5.2.4.

Activity data

The activity data is the total area of agricultural land (arable land, grassland and horticultural land) including areas with cover crops. This data is provided by official statistics.

Table 19: Agricultural land (including areas with cover crops), in [1000*ha]

Arable land and grassland in 1000*ha												
1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
16.597	15.395	15.595	15.674	15.855	15.841	15.789	15.781	15.701	15.694	15.577	15.510	15.465

Methodology

The Tier 2 methodology used is described in EMEP (2023)-3D-22.

Emission factors

Emission factors given in EMEP (2023)-3D-18, Tables 3.6 and 3.8 are used with the exception of „Harvesting“ PM_{10}-factors for Wheat, Rye, Barley and Oat which were taken from the Danish IIR. These Guidebook-EFs are obviously too high by a factor of 10 and were corrected in the Danish IIR.

The missing default-EFs for „other arable“ in the 2023 EMEP/EEA Guidebook were replaced with the average of the EFs of wheat, rye, barley and oat, as it was done in the Danish IIR. The PM_{10} EFs were also used as TSP EFs. The Guidebook does not indicate whether EFs have considered the condensable component (with or without). For details on country specific numbers of agricultural crop operations see Rösemann et al. (2025), Chapter 5.2.4.

Table 20: Implied emission factors for PM emissions from agricultural soils, in kg ha^{-1}

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
TSP	1.41	1.41	1.42	1.40	1.39	1.38	1.37	1.37	1.36	1.36	1.35	1.35	1.36
PM_{10}	1.41	1.41	1.42	1.40	1.39	1.38	1.37	1.37	1.36	1.36	1.35	1.35	1.36
$PM_{2.5}$	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

Trend discussion for Key Sources

TSP and PM_{10} are key sources. Emissions depend on the areas covered, crop types and number of crop operations. With the exception of the numbers of soil cultivations, which is slightly decreasing, these data are relatively constant. Overall this is reflected in a slight decline of emissions in the last 12 years.

Recalculations

For all years, totals of TSP, PM_{10} and $PM_{2.5}$ emissions are higher than those of last year’s submission. This is mostly due to the introduction of cover crops to the calculation method (see main page of the agricultural sector, list of recalculations, No. 2). Further details on recalculations are described in Rösemann et al. (2025), Chapter 1.3.

Table 21: REC-6: Revised particle emissions (TSP, PM_{10} & $PM_{2.5}$), in kilotonnes

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
TOTAL SUSPENDED PARTICLES (TSP)													
current submission	23.45	21.67	22.13	22.01	22.02	21.81	21.65	21.61	21.38	21.32	21.04	21.00	21.02
previous submission	23.45	21.67	22.13	22.01	22.02	21.81	21.65	21.61	21.38	21.32	21.04	20.97	
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	
relative change [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	
PM_{10}													
current submission	23.45	21.67	22.13	22.01	22.02	21.81	21.65	21.61	21.38	21.32	21.04	21.00	21.02
previous submission	23.45	21.67	22.13	22.01	22.02	21.81	21.65	21.61	21.38	21.32	21.04	20.97	
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	
relative change [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	
$PM_{2.5}$													
current submission	1.81	1.70	1.77	1.77	1.77	1.74	1.72	1.72	1.69	1.68	1.65	1.65	1.66
previous submission	1.81	1.70	1.77	1.77	1.77	1.74	1.72	1.72	1.69	1.68	1.65	1.64	
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
relative change [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	

Planned improvements

No improvements are planned at present.

3.D.e - Cultivated crops

In this category Germany reports NMVOC emissions from crop production according to EMEP (2023)-3D-21. For details see Rösemann et al. (2025), Chapter 5.2.3.

Activity data

The *total area of arable land and grassland* applied as activity data is provided by official statistics.

Table 22: Arable land and grassland, in [1000 ha]

1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
16.506	15.312	15.498	15.561	15.734	15.719	15.662	15.647	15.570	15.563	15.447	15.376	15.336

Methodology

The Tier 2 methodology described in EMEP (2023)-3D-21ff is used.

Emission Factors

The emission factors for wheat, rye, rape and grass (15°C) given in EMEP (2023)-3D-21, Table 3.4 were used. For all grassland areas the grass (15°C) EF is used, for all other crops except rye and rape the EF of wheat is used.

The implied emission factors provided in the following table are defined as ratio of the total NMVOC emissions from cultivated crops to the total area given by activity data.

Table 23: IEF for NMVOC emissions from crop production, in [kg ha-1]

1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
0.47	0.53	0.57	0.59	0.61	0.63	0.62	0.62	0.50	0.55	0.59	0.61	0.58

Trend discussion for Key Sources

NMVOC emissions from crop production are no key sources.

Recalculations

There were no recalculations. Further details on recalculations are described in Rösemann et al. (2025), Chapter 1.3.

Table 24: REC-8: Revised NMVOC emissions, in kilotonnes

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
current submission	7.69	8.19	8.79	9.17	9.53	9.91	9.69	9.74	7.82	8.56	9.16	9.44	8.91
previous submission	7.69	8.19	8.79	9.17	9.53	9.91	9.69	9.74	7.82	8.56	9.16	9.43	
absolute change	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
relative change [%]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	

For **pollutant-specific information on recalculated emission estimates for Base Year and 2022**, please see the pollutant specific recalculation tables following chapter 8.1 - Recalculations.

Planned improvements

No improvements are planned at present.

Uncertainty

Details are described in chapter 1.7.

[1], [5]
EMEP/EEA air pollutant emission inventory guidebook 2023, EEA Report No 06/2023, https://www.eea.europa.eu/en/analysis/publications/emep-eea-guidebook-2023.
[2]
Bittman, S., Dedina, M., Howard C.M., Oenema, O., Sutton, M.A., (eds) (2014): Options for Ammonia Mitigation. Guidance from the UNECE task Force on Reactive Nitrogen. Centre for Ecology and Hydrology, Edinburgh, UK.
[3], [6], [7], [9], [10], [11], [12]
Rösemann, C., Vos, C., Haenel, H.-D., Dämmgen, U., Döring, U., Wulf, S., Eurich-Menden, B., Freibauer, A., Döhler, H., Schreiner, C., Osterburg, B., Fuß,R. (2025) Calculations of gaseous and particulate emissions from German agriculture 1990 – 2023 : Report on methods and data (RMD) Submission 2024. www.eminv-agriculture.de
[4]
Stehfest E., Bouwman L. (2006): N2O and NO emission from agricultural fields and soils under natural vegetation: summarizing available measurement data and modelling of global emissions. Nutr. Cycl. Agroecosyst. 74, 207 – 228.
[8]
NID (2025): National Inventory Report 2025 for the German Greenhouse Gas Inventory 1990-2022. Available in April 2025.