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.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	Agriculture: Other (including 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.c	NA	NA	NA	NA	-/-	**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 2022, agricultural soils emitted 267.8 kt NH_3 or 57.1 % of the total agricultural NH_3 emissions in Germany (469.3 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 165.8 kt (61.9 %) and the application of other organic N-fertilizers (3.D.a.2.c) with 54.2 kt (20.2 %).

Application of synthetic N-fertilizers (3.D.a.1) contributes 33.4 kt NH_3 (12.5 %). N excretions on pastures (3.D.a.3) have a share of 12.8 kt NH_3 (4.8 %) and the application of sewage sludge (3.D.a.2.b) leads to 1.6 kt NH_3 (0.6 %).

In 2022, agricultural soils were the source of 98.6 % (99.9 kt) of the total of NO_x emissions in the agricultural category (101.3 kt). The NO_x emissions from agricultural soils are primarily due to application of inorganic fertilizer (3.D.a.1) (45.5 kt) and manure (3.D.a.2.a) (35.2 kt) Application of other organic N-fertilizers (3.D.a.2.c) contributes 13.9 kt to agricultural soil emissions, 4.8 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 2022, the category of agricultural soils contributed 8.9 kt NMVOC or 3.1 % to the total agricultural NMVOC emissions in Germany. The only emission source was cultivated crops (3.D.e).

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

In 2022, agricultural soils contributed, respectively, 35.6 % (21.0 kt), 63.4 % (21.0 kt) and 31.4 % (1.7 kt) to the total agricultural TSP, PM_{10} and $PM_{2.5}$ emissions (59.1 kt, 33.1 kt, 5.3 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 Vos et al. (2024), Chapter 2.8.

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

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 the application of synthetic fertilizers are calculated using the Tier 2 approach according to EMEP (2019)-3D-14ff [1], distinguishing between various fertilizer types, see Table 2. For NO_x, the Tier 1 approach described in EMEP (2019) [10]-3D-11 is applied.

Emission factors

The emission factors for NH_3 depend on fertilizer type, see EMEP (2019)-3D-15. 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 Vos et al. (2024), 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	0.008
ammonia nitrate urea solutions (AHL)	0.098
urea (up to 2019)	0.155
urea (from 2020 with urease inhibitor)	0.062
urea (from 2020 if incorporated)	0.0465
ammonium phosphates	0.050
other NK and NPK	0.050
other straight fertilizers	0.010

For NO_x, the simpler methodology by EMEP (2019)-3D-11 was used. The emission factor 0.040 from EMEP, 2019-3D, Table 3.1 has the units of kg N2O per kg fertilizer N and was derived from [3]. The German inventory uses the emission factor 0.012 kg NO-N per kg N derived from Stehfest and Bouwman (2006). 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 (R² = 0.89), 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. Major differences for NH_3 emissions occur in 2020 and 2021 because of the new reduction factor for the use of urease inhibitors and to a much lesser extent resulting from the moving average. The latter is the only reason for the differences of NO_x emissions in 2021. Minor differences occur in some years before 2008. They result from the correction of the applied amounts (**recalculation No. 12**).

Table 4: REC-1: 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	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
previous submission	78.82	69.56	85.64	86.36	88.43	97.89	99.73	89.25	76.79	65.63	35.94	34.87	
absolute change	-0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.15	
relative change [%]	-0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.94	0.44	-0.14
Nitrogen oxides													
current submission	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
previous submission	86.57	67.94	75.77	70.84	64.48	68.46	68.24	63.95	59.11	55.34	52.31	51.30	
absolute change	-0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-2.22	
relative change [%]	-0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-4.32	

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 Vos et al. (2024), 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 Vos et al. (2024), Chapter 2.5. The frequencies are provided. in the NID 2024[4], 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 Vos et al. (2024), Chapter 5.2.1.2. For NO_x emissions from manure application the inventory calculates NO-N emissions (see Vos et al. (2024), 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 (2019)-3D-11 is used, as no specific methodology is available for manure application.

Emission factors

Table 5 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 5. 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

Table 7 shows the effects of recalculations on NH_3 and NO_x. 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. Most of the recalculations (except No. 2, 11, 12) have an effect on this, some are increasing the emissions (esp. **No. 1** (new animal categories) and **No. 6** (correction of poultry numbers before 2013). **Recalculation No. 13** (update of anaerobic digestion data) results to changes in both directions for different animal categories, see main page of the agricultural sector, list of recalculation reasons. Further details on recalculations are described in Vos et al. (2024), 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	
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 Vos et al. (2024), 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 (see Table 7).

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, 2019, 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 (2019)-3.D, Table 3-1 provides a Tier 1 emission factor for NH_3 (0.13 kg NH3 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 (2019)-3D, page 26-27). 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

Table 8 shows the effects of recalculations on NH_3 and NO_x emissions. Due to an update of the activity data the emission estimates are different compared to the last submission in most years, sometimes higher and sometimes lower (see main page of the agricultural sector, **recalculation No. 12**). Further details on recalculations are described in Vos et al. (2024), Chapter 1.3.

Table 8: 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	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	

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
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 Vos et al. (2024), 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 Vos et al. (2024), 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 Vos et al. (2024), 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 Vos et al. (2024), Chapter 2.8.

Table 9: AD for the estimation of NH_3 and NO_x emissions emissions from application of other organic fertilizers

	Application of other organic fertilizers in Gg 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 2024, 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 Vos et al. 2024, Chapter 2.8.

For NO_x emissions the Tier 1 approach for the application of synthetic fertilizer as described in EMEP (2019)-3D-11 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 Vos et al. (2024), 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 10 shows the implied emission factors for NH_3 emissions from application of other organic fertilizers.

Table 10: 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

Table 11 shows the effects of recalculations on NH_3 and NO_x emissions. For all years the total emissions of NH_3 and NO_x from application of other organic fertilizers are significantly higher than those of last year’s submission. The main reason for that is, that the emissions from application of residues from digested waste, compost of biowaste and compost of green waste are reported for the first time in the agriculture sector (see main page of the agricultural sector, list of recalculation **reasons, No 2**, and Vos et al. (2024), Chapter 1.3)

Table 11:REC-4: Comparison of the NH3 and NOx emissions from application of other organic fertilizers of the submissions (SUB) 2022 and 2023

NH3 and NOx emissions from application of other organic fertilizers, in Gg														
	SUB	1990	1995	2000	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
NH3	2024	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
NH3	2023	0.24	1.12	3.15	60.14	60.84	60.66	58.87	56.82	55.02	53.96	54.33	54.31	
relative 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	
absolute 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	
NOx	2024	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
NOx	2023	0.22	0.99	1.83	12.76	13.53	14.00	13.95	13.71	13.68	13.68	14.00	13.99	
relative 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	
absolute 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 Vos et al. (2024), 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 on pasture.

Table 12 shows the share of N excretions on pasture. 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 12: Share of N excretions on pasture

	N excretions on pasture in % of total N excreted												
	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
Ostriches	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 9). The result is multiplied with the animal specific emission factor (Table 10). 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 (2019)-3B-31, 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 Vos et al. 2024, 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, 2019-3D, 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 13: Emission factors for emissions of NH_3 and NO from grazing

Emission factors	
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

Table 14 shows the effects of recalculations on NH_3 and NO_x emissions.

For all years the total emissions of NH_3 and NO_x from grazing are slightly higher than those of last year’s submission. The main reason for that is the introduction of the new animal categories ostrich and deer. It is assumed that rabbits and fur bearing animals do not have access to pasture (see main page of the agricultural sector, list of recalculations, No. 1). Further details on recalculations are described in Vos et al. (2024), Chapter 1.3.

Table 14: 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.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 (2019)-3D-17. For details see Vos et al. (2024), Chapter 5.2.4.

Activity data

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

*Table 15: AD for the estimation of TSP, PM_{10} and $PM_{2.5}$ emissions from soils^*

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 (2019)-3D-17.

Emission factors

Emission factors given in EMEP (2019)-3D-18, Tables 3.5 and 3.7 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 2019 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 Vos et al. (2024), Chapter 5.2.4. Table 12 shows the implied emission factors for PM emissions from soils.

Table 16: Emission factors for PM emissions from agricultural soils

	IEF 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
PM10	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
PM2.5	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

Table 17 shows the effects of recalculations on particulate matter emissions. The only difference is in the year 2021, where the emissions are slightly higher than in the submission 2023. The reason for this is the correction of area data in one federal state.Further details on recalculations are described in Vos et al. (2024), Chapter 1.3.

Table 17: REC-6: Comparison of particle emissions (TSP, PM_{10} & $PM_{2.5}$) of the submissions (SUB) 2023 and 2024

TSP, PM10, PM2.5 emissions from crop production, in Gg														
	SUB	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019	2020	2021	2022
TSP	2024	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
TSP	2023	23.45	21.67	22.13	22.01	22.02	21.81	21.65	21.61	21.38	21.32	21.04	20.97	
relative change		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	
absolute change [%]		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	
PM10	2024	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
PM10	2023	23.45	21.67	22.13	22.01	22.02	21.81	21.65	21.61	21.38	21.32	21.04	20.97	
relative change		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	
absolute change [%]		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	
PM2.5	2024	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
PM2.5	2023	1.81	1.70	1.77	1.77	1.77	1.74	1.72	1.72	1.69	1.68	1.65	1.64	
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	
absolute change [%]		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	

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 (2019)-3D-16. For details see Vos et al. (2024), Chapter 5.2.3.

Activity data

The activity data is the total area of arable land and grassland. This data is provided by official statistics.

Table 18: AD for the estimation of NMVOC emissions from crop production

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 (2019)-3D-16ff is used.

Emission Factors

The emission factors for wheat, rye, rape and grass (15°C) given in EMEP (2019)-3D-16, Table 3.3 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. Table 19 shows the implied emission factors for NMVOC emissions from crop production. The implied emission factor is defined as ratio of the total NMVOC emissions from cultivated crops to the total area given by activity data.

Table 19: 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

Table 20 shows the effects of recalculations on NMVOC emissions. The only change with respect to last year's submission is in 2021, where emissions are slightly higher in the present submission. The reason for this is the correction of area data in one federal state. Further details on recalculations are described in Vos et al. (2024), Chapter 1.3.

Table 20: REC-7: 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 2020**, 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]
EMEP (2019): EMEP/EEA air pollutant emission inventory guidebook – 2019, EEA Report No 13/2019, https://www.eea.europa.eu/publications/emep-eea-guidebook-2019.
[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]
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.
[4]
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