Notitie

Earth, Life & Social Sciences
Princetonlaan 6
3584 CB Utrecht
Postbus 80015
3508 TA Utrecht

www.tno.nl

T +31 88 866 42 56
F +31 88 866 44 75

Aan
Wim van der Maas

Van
Ing. B.I. Jansen

Onderwerp
Ammoniak emissies in huishoudens

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E-mail
bart.jansen@tno.nl

Doorkiesnummer
+31 88 866 20 88

Doorkiesfax
+31 88 866 20 44

Inleiding

De meeste ammoniak emissies in Nederland worden uitgestoten door de landbouw. In totaal werd in Nederland 138.2 kton ammoniak geëmitteerd, waarvan 117 kton door de landbouw (in 2014). In de berekening uit 2015 wordt door consumenten 7.2 kton ammoniak uitgestoten (mestgebruik op natuurterreinen en bij particulieren uitgesloten). Als gevolg van de dalende emissies van ammoniak in de loop der jaren wordt er steeds meer nadruk gelegd op deze consumenten emissie. In deze notitie wordt ingegaan op de wijzigingen die in 2016 zijn doorgevoerd in de consumenten emissies die allen onder de taakgroep WESP vallen. In de samenvatting wordt eerst beschreven welke wijzigingen zijn doorgevoerd in emissies, vervolgens wordt per emissieoorzaak beschreven welke emissiefactoren en activiteitsdata gewijzigd zijn. In de bijlage worden de hoofdstukken uit het WESP methodiek rapport weergegeven die gewijzigd zijn, deze zijn wel Engelstalig.

Samenvatting

De emissies van ammoniak veroorzaakt door consumenten bestaat uit de volgende bronnen met bijbehorende emissies volgens de berekeningsmethodes uit 2015:

- Transpiratie en ademen 5.1 kton
- Mest van huisdieren 1.5 kton
- Schoonmaakmiddelen 0.5 kton
- Roken van sigaretten en sigaren 0.2 kton

Met een totaal van 7.3 kton ammoniak emissies in 2014.

De ammoniakemissies van consumenten zijn in 2016 opnieuw bekeken. De doorgevoerde wijzigingen hebben geleid tot de aanpassing van emissies tot:

- Transpiratie en ademen 1.4 kton
- Mest van huisdieren 1.6 kton
- Schoonmaakmiddelen 0.3 kton
- Roken van sigaren en sigaretten 0.2 kton

De totale emissie van huishoudens wordt 3.5 kton NH3 in 2014. De berekening voor het roken van sigaren en sigaretten is niet herzien.

Transpiratie en ademen

De ammoniak emissie door menselijk transpireren en ademen wordt bepaald uit de hoeveelheid inwoners en een emissiefactor per inwoner. De hoeveelheid inwoners is in de berekeningen niet gewijzigd, dit was en blijft voor het jaar 2014 16.9 miljoen.
De emissiefactor die in de berekeningen gebruikt werd, stond op 300 g per inwoner per jaar. Gebaseerd op nieuwe inzichten, is dit aangepast naar 83 g per inwoner per jaar.
De bijbehorende berekening is dan;
Voor de 'oude' 2015 berekening: 16.9 * 300 = 5.1 kton
Voor de 'nieuwe' 2016 berekening: 16.9 * 83 = 1.4 kton

Mest van huisdieren

De ammoniak emissies uit de mest van huisdieren werd in de 2015 berekening bepaald door het aantal huishoudens (7.5 miljoen) te vermenigvuldigen met een emissiefactor per huishouden (200 g).
De bijbehorende berekening voor 2014 is dan; 7.5 * 200 = 1.5 kton

Voor de in 2016 doorgevoerde berekening worden de emissies van honden en katten berekend en gecorrigeerd voor de andere huisdieren. Voor honden geldt dat er in 2014 1.5 miljoen waren, met een emissiefactor van 610 gram per hond per jaar. Voor katten geldt dat er 2.6 miljoen waren in 2014, met een emissiefactor van 110 gram per kat per jaar. Nadat de emissies van honden en katten berekend zijn, worden deze opgeteld en verhoogd met 33%.
Dit lijdt tot de volgende berekening voor 2014; 4/3 * (1.5 * 610 + 2.6 * 110) = 1.6 kton

Schoonmaakmiddelen

De berekening van de ammoniak emissie van huishoudelijke producten (schoonmaakmiddelen) is voor het laatst uitgevoerd in 2003 en sindsdien constant gehouden. In 2003 werd de emissie geschat op 0.5 kton. De verouderde WESP methode beschrijving meldt dat voor 1990 een emissie van 1000 ton geschat werd en deze emissie is verdeeld tussen HDO en consumenten.
De in 2016 voorgestelde emissieberekening gaat (alleen voor consumenten, niet voor HDO) uit van het aantal huishoudens en een emissiefactor van 36 gram per huishouden per jaar.
De bijbehorende berekening voor het jaar 2014 is dan; 7.5 * 36 = 0.3 kton

Bijlage: Transpiratie en ademen

Human ammonia emissions from transpiration and breathing

In this paragraph the emissions of NH_3 from human transpiration and breathing are described.

Process description	Emk_code	NFR_code	Sector
Human transpiration and breathing	0801600	11.C	Consumers

Description emission source

This emission source describes the ammonia emissions from humans by sweating and breathing. Through the consumption of food, nitrogen (N) is introduced in our system and afterwards is disposed again. Most nitrogen is released into the sewer system, the ammonia released through sweating and breathing is calculated within this emission source.

Contribution to the national emission
The contribution of this source to the total national NH_3 emission is around 1% (based on 2014).

Calculation

For the complete time series, the emissions are calculated as follows.

Emission = Activity data x Emission factor
Activity data = the amount of Dutch inhabitants
Emission factor = kg emission per inhabitant

a) Activity data

The amount of inhabitants in the Netherlands is derived from CBS Statline on annual basis. The amount of people living in the Netherlands at the end of June in a specific year is taken as activity data for that year.

b) Emission factor

With the food humans consume, also nitrogen (N) is consumed. It is estimated that a human excretes though different ways (urine, sweat, faeces etc.) 5 kg N (NH_3) per year (Battye et al 1994). Most N or NH_3 is released with the urine (and faeces) and is supposed to go through the sewer system.
The first emission factor used by the Dutch emission inventory was based on van der Hoek 1994. This report mentioned a total emission factor of 0.7 kg NH_3 per inhabitant per year, combining 0.3 kg NH3 from sweating and breathing, use of

ammonia as cleaning product (1 litre of ammonia solution per household) and the ammonia emissions of cats and dogs.
Another report (Bouwman et al 1997) mentions an emission factor of the same magnitude for human emission of NH_3. In this study the emissions calculated are used for a global emission inventory. The author mentions that it's difficult to come to a well estimated emission factor, but describes that this source should not be neglected. Therefore he assumes 0.5 kg NH_3 per person per year, independent of sanitary arrangements and including domestic pets (cats/dogs). Since the Dutch standard includes a good sewer system and the Netherlands reports the emissions of domestic pets separately, this emission factor is considered to be too high for the Netherlands.
In Joshua Fu et al 2010 is mentioned that, perspiration, respiration, untreated waste, cigarettes, household ammonia use, diapers and homeless people are sources of ammonia emissions directly caused by humans. Joshua Fu et al 2010 reports an emission factor of 0.44 kg NH3 per person per year for all these emission sources combined. No separate emission factors are presented, though de distribution of the emission on the different sources is reported. Both perspiration and respiration are reported to contribute about 40% each. The emissions of untreated waste, household ammonia use and homeless people contribute about 4-6% each. Cigarettes, (untreated) waste and household ammonia are sources that are included as separate sources in the Dutch emission inventory. Also other studies report that the emissions of breathing are less than the emissions of sweating. Therefore the emissions in this document could be too high for the Netherlands.
In Battye et al 1994 different references are considered, varying from 0.25-1.3 kg NH_3/human/year from breathing and sweating. Although it's mentioned that further research is needed, it's recommended to use the emission factor of 0.25 kg NH_3 p.p.p.y. and that this emission factor is retrieved from a NAPAP report. Most interesting aspect is the reference to a measurement of NH_3 in a home. It is mentioned that an emission factor of 1 kg NH_3 should result in a concentration of about 431 µg/m^3, while the concentrations measured are between 32 and 39 µg/m^3. It might be concluded, although this is not done within this study, that the emission factor should be around 0.1 kg NH_3 per person and per year.
One of the most comprehensive studies on the emissions of ammonia from non-agricultural sources, is conducted by Sutton et al 2000. In this report the emissions of sweating are calculated with a range of emission factors from 2.08 g NH_3 till 74.88 g NH_3 per person and year. For breathing the range is 1.0-7.7 g NH3 per person per year. Sutton et al 2000 references to a number of other reports and explains his assumptions. One of the most important assumptions made is the amount of NH_3 that volatilizes from sweat (10-30%). If no volatilisation is assumed the high end emission factor is about 0.25 kg NH_3 per person and per year. This is equal to Battye et al 1994 and a reference used by Sutton et al 2000.
Furthermore some studies (Chang 2014, Zheng et al 2012 and Klimont&Brink 2004) found on ammonia emissions, all use the emission factors presented by Sutton et al 2000.
Some countries other than the Netherlands also report the emissions of human sweating and breathing, for example Switzerland, Canada and the UK (in the past). The three countries mentioned used the 'best' emission factors provided by

Sutton et al 2000 of 0.017 kg NH_3 p.p.p.y. This is less than the ammonia emission factor in the guidebook 2013 of 0.05 kg NH_3 per person and year.
Only one study found (Sutton et al 2000) reports an emission factor for the ammonia emissions from diapers. Depending on the age and some assumptions made, the emission factor ranges from 2.4-68 g NH_3 per infant and per year. A first estimate for children (age 0-3 year) in the Netherlands gives an emission of 2 till 50 tonnes NH_3 a year. Since this is only one reference and a relative low contribution to the national total, the decision is made not to include this emission (separately) in the Dutch emission inventory.

Emission factor used in the Netherlands emissions inventory:
The high end emission factors of Sutton et al 2000 are used, resulting in a total emission factor of 0.0826 kg NH_3 per person per year (sum of 74.88 and 7.7 gram p.p.p.y. for sweating and respiration respectively). Because the emission factors in other reports are higher, it is decided to choose the high end emission factors of Sutton et al 2000, instead of the 'best' emission factors. This way the risk of underestimating the human ammonia emissions is reduced and emission sources not calculated (homeless people and diapers) can be neglected.

Uncertainty and Quality checks

The uncertainty in the number of inhabitants in the Netherlands is considered to be very small, therefore the uncertainty is qualified as A.
The uncertainty in the emission factor is estimated to be relative high, since emission factors vary between different sources and the amount of ammonia volatilized is based on an assumption. Hence the uncertainty is qualified as D.

Quality codes

Substance	Activity data	Emission factor	Emission
NH_3	A	D	C

Quality checks
There are no sector specific quality checks performed. For the general QA/QC, see chapter 2.

Spatial allocation

The ammonia emissions of humans are spatially allocated in the Netherlands based on the inhabitants.

Emission source/process	Allocation-parameter
Human ammonia emission; sweating and breathing	inhabitants

Details available via
http://www.emissieregistratie.nl/erpubliek/misc/documenten.aspx?ROOT=Algemeen (General)\Ruimtelijke toedeling (Spatial allocation)

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Responsibility manager task group WESP:

Administrator	Organisation	E-mail address
B.I. Jansen	TNO	bart.jansen@tno.nl

Bijlage: Mest van huisdieren

Manure of Domestic animals

In this paragraph the emissions of NH_3 caused by domestic animals are described.

Process description	Emk_code	NFR_code	Sector
Manure of domestic animals	0802000		Consumers

Description emission source

Within this emission source the emissions of domestic animals are calculated. Domestic animals are defined as animals not used as livestock in the agricultural industry, with the exception of horses, ponies and goats, which are calculated by the taskforce agriculture and nature. When animals consume food, the nitrogen (N) from the food is (partly) released again. Most N is released through the excretion of faeces and urine, which results in the emission of ammonia. Emissions of other substances caused by domestic animals are considered irrelevant and therefore are not calculated.

Contribution to the national emission
The contribution of this source to the total national NH_3 emission is around 1%, based on 2014 emissions.

Calculation

For the complete time series, the emissions are calculated as follows
Emission = 4/3 * Σ(Activity data x Emission factor)

Activity data = Amount of animals per type
Emission factor = kg NH3 per animal type
The $4/3^{th}$ is a correction for animals missing in the activity data and emission factors.

a) Activity data

The activity data is based on data retrieved from DIBEVO, a branch organisation for animal supplies. There are more sources that report animal numbers, for example WUR 2015 published a report on the amount of cats in 2015 (3.5 million excluding stray cats) and an article on nu.nl reported for 2005 3.3 million cats and 1.8 million dogs. Besides an estimate of Booij 1995, no source produced an estimate on the amount of many other domestic animals than cats and dogs. Therefore the best estimate for the emissions of domestic animals is based on the number of cats and dogs.

b) Emission factor

The previous emission factor used by the Dutch emission inventory by was based on Booij 1995, who calculated a total emission of 1220 tonne NH_3 from all domestic animals (cats, dogs, rabbits and birds) for the year 1990. The emission factors for cats and dogs calculated by Booij 1995 are respectively 0.18 and 0.36 kg NH_3 per animal and per year. The emission calculated for cats and dogs by Booij 1995 is about 70% from the total NH_3 emission from pets.
Some other authors Joshua Fu et al 2010 and Bouwman et al 1997 report emission factors of around 0.7 kg NH_3 per year for cats and around 2 kg NH_3 per year for dogs. This seems high compared to Booij 1995. Furthermore most other reports seem to base their emission factor on the work of Sutton et al 2000. The presented emission factor in Sutton et al 2000 is 0.61 kg NH_3 for dogs and 0.11 kg NH_3 for cats each per animal and per year.
Based on these studies the emission factors for cats and dogs from Sutton et al 2000 are used. The sum of the emissions calculated for cats and dogs are multiplied by 4/3th, to correct for the emissions of the domestic animals not calculated.

Uncertainty and Quality checks

The amount of cats and dogs are based on a yearly survey conducted by order of DIBEVO. A sample survey generally has a relatively high uncertainty due to the amount of respondents. Besides the other animals are not taken into account. Therefore the uncertainty is qualified as a D.
In Sutton et al 2000 the uncertainty range provided is 50%. However the emission factors according to the other studies can be higher than that. Therefore the uncertainty is qualified as a D.
The uncertainty of the total emissions is higher than the uncertainty in the activity data and the emission factor, because the correction for the other animals is less certain than the emission for cats and dogs. Therefore the uncertainty in the total emission is qualified as an E.

Quality codes

Substance	Activity data	Emission factor	Emission
NH_3	D	D	E

Quality checks
There are no sector specific quality checks performed. For the general QA/QC, see chapter 2.

Spatial allocation

The emissions of ammonia from the manure of domestic animals are spatially allocated in the Netherlands based on inhabitants.

Emission source/process	Allocation-parameter
Manure of domestic animals	Inhabitants

Details available via
http://www.emissieregistratie.nl/erpubliek/misc/documenten.aspx?ROOT=Algemeen (General)\Ruimtelijke toedeling (Spatial allocation)

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B.I. Jansen	TNO	bart.jansen@tno.nl

Bijlage: Schoonmaakmiddelen

Solvent and other product use: detergents

In this paragraph the emissions of NH_3 caused by detergents are described.

Process description	Emk_code	NFR_code	Sector
Solvent and other product use: detergents	0803000		Consumers
Solvent and other product use: detergents	0803001		HDO

Description emission source

Within this emission source the emissions of detergents are calculated. Detergents are used by Consumers and service and trade companies. Most detergents emit NMVOC, however ammonia solution is also used for cleaning. So far this document only describes the emissions of ammonia. The emissions of NMVOC needs to be added.

Contribution to the national emission
The contribution of this source to the total national NH_3 emission is <0.5%, based on 2014 emissions.

Calculation

The ammonia emission for HDO (service and trade companies) is not calculated since 2003, but is set to a steady number, which is around 0.5 kton per year.

The emission of ammonia from households is calculated for the complete time series as follows.
Emission = Activity data x Emission factor
Activity data = Amount of households
Emission factor = kg NH3 per household

a) Activity data

As activity data to calculate the emissions from ammonia from household detergent use, the amount of households is used. The amount of households in the Netherlands is retrieved from the national statistics bureau.

b) Emission factor

In the past the emission factor used for the release of ammonia as a result of detergent was based on the assumed use of 1 litre ammonia solution per household, containing 25% ammonia. And a total emission of 1000 ton NH_3 per

year. The total use of ammonia was distributed between the sectors consumers and 'service and trade companies' with an even distribution of 50%. This calculation was based on research by the van der Hoek 1994 and Erisman 1989. In the current calculation an emission factor of 36 gram NH_3 per household is used. This is based on Sutton et al 2000, who reports an emission for the UK by the use of ammonia solution. If this emission is divided by the amount of households of the UK, an emission factor of 36 gram NH3 per household can be calculated (with a range of 10-150 gram per year per household).

Uncertainty and Quality checks

The uncertainty for ammonia emission has to be divided for the sectors consumer and trade and services, since the calculation is different.
For trade and services only the uncertainty in the total emissions is estimated, since the background of the calculation is not researched. The uncertainty is estimated to be an E, since the emission is not updated since 2003 and the calculation was based on a research from 1994.
The uncertainty in the amount of households is small, since the statistics provided are reliable and are therefore qualified as A. The uncertainty in the emission factor is estimated to be an D, based on the range given in Sutton et al 2000 and the fact it's only based on that single research.

Quality codes

Substance	Activity data	Emission factor	Emission
NH_3 (Trade and services)	Not estimated	Not estimated	E
NH_3 (Consumers)	A	D	D

Quality checks
There are no sector specific quality checks performed. For the general QA/QC, see chapter 2.

Spatial allocation

The emissions from detergents are spatially allocated in the Netherlands based on inhabitants.

Emission source/process	Allocation-parameter
Solvent and other product use: detergents	Inhabitants

Details available via
http://www.emissieregistratie.nl/erpubliek/misc/documenten.aspx?ROOT=Algemeen (General)\Ruimtelijke toedeling (Spatial allocation)

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