Technical process description AGRAMMON Draft

Agrammon Group

2009-10-12/ 1230

Contents

1 Introduction

AGRAMMON is a model to simulate ammonia emission from farming. It considers livestock (housing, yard, grazing), storage, application, and plant production emissions of seven different animal categories including 26 animal species. The most common housing systems for dairy cows, cattle (tied and loose) and pigs (conventional ans label) are considered as well as several different application techniques. Ammonia emission of a single farm and of entire Switzerland can be calculated. AGRAMMON has been developed by a group of agronomists (SHL, Zollikofen), environmental scientists (Bonjour Engineering GmbH, Lostorf) and computer scientists (Oetiker+Partner AG, Olten) on behalf of the Federal Office for the Environment (FOEN, Ittigen).

The Model is availabel for calculation under `http://www.agrammon.ch`.

1.1 Structure of the model:

The model consists of computing modules, technical parameters and input parameters.

The **input parameters** include terms such as animal categories, number of animals, details on animal feeding, housing system, storage, application, and plant production. These parameters must be defined by the model users.

The **technical parameters** include terms such as emission rates, emission factors, mobilisation- and immobilisation rates of ammonia and ammonium, proportions of solid and liquid share of the manure. Further information about animal feed like the composition and the amount of the feed, the energy content, and the crude protein content are defined in this section. The technical parameters are assembled by the modellers considering the most recent research results as well as international guidelines (e.g. UNECE 2007) adopted for Switzerland. They can not be changed by the model users.

The process which calculates the ammonia emission by using the input and the technical parameters is split into four main computing modules: production (including excretion, housing, yard, grazing), storage, application, and plant production (see Figure 1). Each module is divided into a number of submodules.

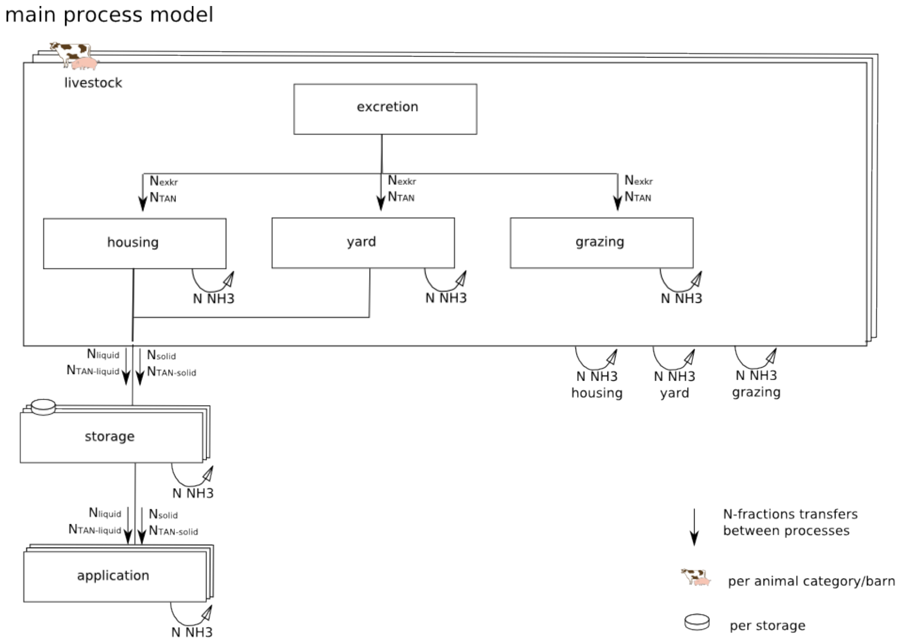

Figure 1: AGRAMMON process structure: livestock, storage, application, plant production

1.2 Structure of the description:

This technical process description shows the modules and submodules, followed by the overall used input parameters and technical parameters summarised in two tables at the end the document.

Modules and submodules are designed in a standardised manner with the following sections: short description, input parameters, technical parameters, output, detailed process description. The short description gives a one line description of the module. Input parameter, technical parameter and output are listed in tables together with unit, value (tech. parameter), formula (output) and description (input and tech. parameter). The detailed process description gives additional information about the process including references.

2 Application

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2.1 Short description

Computes the annual NH3 emission from application.

2.2 Input parameters

2.3 Technical parameters

2.4 Output

Parameter	Unit	Formula
tan_out_application	kg TAN /a	Annual TAN flux out of the application. Val(tan_into_application, Storage) - (Val(nh3_nliquid, Application::Slurry) + Val(nh3_nsolid, Application::SolidManure))
nh3_napplication	kg N /a	Annual NH3 emission from manure application. Val(nh3_nliquid, Application::Slurry) + Val(nh3_nsolid, Application::SolidManure)
nh3_napplication_solid	kg N /a	Annual NH3 emission from solid manure application. Val(nh3_nsolid, Application::SolidManure);
n_out_application	kg N /a	Annual N flux out of the application. Val(n_into_application, Storage) - (Val(nh3_nliquid, Application::Slurry) + Val(nh3_nsolid, Application::SolidManure))
nh3_napplication_liquid	kg N /a	Annual NH3 emission from liquid manure application. Val(nh3_nliquid, Application::Slurry);

2.5 Detailed process description

This process summarizes the contribution of the individual manure systems to the total NH3 emission from manure application.

2.5.1 Differences to DYNAMO

The categories "Soil absorptive" and "application before rain" are omitted since the practice is unknown and experimental results are not available (according to the decision of the steering group from 02/07/2007).

The distinction between the categories incorporation of solid manure by chisel plough or plough are omitted since the difference is unclear (according to the decision of the steering group from 02/07/2007).

The category "rapid incorporation" is replaced by "application manure" since slurry is hardly incorporated in Switzerland. The entire category is adapted to UNECE (2007) including new categories.

3 Application::Slurry

Agrammon Group – 13-11-09

3.1 Short description

Computes the annual NH3 emission from slurry application.

3.2 Input parameters

3.3 Technical parameters

Parameter	Value	Unit	Description
er_App_cattle_liquid	0.5	-	Emission rate for slurry application based on TAN of the slurry. The average rate has been derived from Sommer (2001b), Sogaard et al. (2002), Menzi et al. (1998), Menzi et al. (1997a)
er_App_pigs_liquid	0.35	-	Die Emissionsrate wurde gemäss ALFAM Modell (Sogaard et al., 2002) berechnet mit folgenden Inputdaten: durchschnittliche Temperatur von März bis November: 12°C (Daten SMA Station Bern Liebefeld 1993-2002); Windgeschwindigkeit von 1 m/s: Schweinegülle Mast: TAN Gehalt Gülle: 2.1 kg/m3 (Verdünnung 1:1, d.h. 2.5 % TS gemäss Flisch et al., 2009); ohne Korrekturen für emissionsminderende Ausbringung, ohne Einarbeitung nach Ausbringung; Ausbringungsmenge: 30 m3/ha; mikrometeorologische Messung: 30.3 % TAN (Mittelwert Boden feucht, Boden trocken). Bei gleichen Annahmen, jedoch einer reduzierten Ausbringungsmenge von 20 m3/ha (aufgrund des im Vergleich zu Rindergülle höheren TAN-Gehalts) und eines TS Gehalts von 3 % (höherer Strohanteil bei Labelsystemen): 33.2 %. Unter den analogen Annahmen resultieren für Schweinegülle Zucht (TAN Gehalt Gülle: 1.65 kg/m3; Verdünnung 1:1, d.h. 2.5 % TS gemäss Flisch et al., 2009) Emissionsraten von 32.9 % bzw. 36.2 % TAN.

3.4 Output

Parameter	Unit	Formula

er_App_liquid	-	Emission rate for slurry application based on TAN of the slurry. The average rate has been derived from Sommer (2001b), Sogaard et al. (2002), Menzi et al (1998), Menzi et al. (1997a) and Sogaard et al. (2002)
		
		if(Val(n_into_storage_liquid, ::Livestock) != 0){
		return (Val(n_into_storage_liquid_pigs, ::Livestock) × Tech(er_App_pigs_liquid) +
		(Val(n_into_storage_liquid, ::Livestock) -
		Val(n_into_storage_liquid_pigs, ::Livestock)) × Tech(er_App_cattle_liquid))
		/ Val(n_into_storage_liquid, ::Livestock)
		}else{
		return (Tech(er_App_cattle_liquid) + Tech(er_App_pigs_liquid))/2;
		};

n_remain_liquid	kg N /a	Annual total N remaining on the field from slurry application. Val(n_into_application_liquid, ::Storage) - Out(nh3_nliquid);

nh3_nliquid	kg N /a	Total annual NH3 emission from slurry application. Val(tan_into_application_liquid, ::Storage) × (Out(er_App_liquid) + Val(c_app, Slurry::Applrate)) × Val(c_tech, Slurry::Ctech) × Val(c_soft, Slurry::Csoft) × Val(c_season, Slurry::Cseason);
tan_remain_liquid	kg N /a	Annual N as TAN remaining on field the from slurry/liquid application. Val(tan_into_application_liquid, ::Storage) - Out(nh3_nliquid);

3.5 Detailed process description

This process computes the annual NH3 emission from slurry application. The standard emission factor for slurry application is corrected according to the TAN content and the application rate, the application technology, the crops to which the manure is applied, soft measures applied during application and the application season.

Since slurry is hardly incorporated in Switzerland, no correction for incorporeation was made for slurry application.

3.5.1 References:

Flisch R, Sinaj S, Charles R, Richner W 2009. Grundlagen für die die Düngung im Acker- und Futterbau. Agrarforschung 16(2).

Frick R, Menzi H, Katz P 1996. Ammoniakverluste nach der Hofdüngeranwendung. FAT-Bericht Nr. 486.

Katz P E 1996. Dissertation: Ammoniakemissionen nach der Gülleanwendung auf Grünland. Diss. ETH Nr. 11382. Dissertation. Eidgenössische Technische Hochschule Zürich.

Menzi H, Frick R, Kaufmann R 1997a. Ammoniak-Emissionen in der Schweiz: Ausmass und technische Beurteilung des Reduktionspotentials. Eidgenössische Forschungsanstalt für Agrarökologie und Landbau, Zürich-Reckenholz. 107pp.

Menzi H, Katz, PE, Fahrni M, Neftel A, Frick R 1998. A simple empirical model based on regression analysis to estimate ammonia emissions after manure application. Atmospheric Environment 32:301-307.

Sogaard H T, Sommer S G, Hutchings N J, Huijsmans J F M, Bussink D W, Nicholson F 2002. Ammonia volatilization from field-applied animal slurry - the ALFAM model. Atmospheric Environment 36: 3309-3319.

Sommer S G 2001b. Effect of coposting on nutrient loss and nitrogen availability of cattle deep litter. European Journal of Agronomy 14: 123-133.

4 Application::Slurry::Applrate

Agrammon Group – 13-11-09

4.1 Short description

Correction factor taking into account the slurry application rate per ha and the TAN content of the slurry as compared to the emission rate occurring with a standard application rate of 30 m3 and a TAN content of 1.15 kg N /m3.

4.2 Input parameters

Parameter	Unit	Description
dilution_parts_water	1:x	Specific slurry dilution. TAN contents have been calculated based on a standard dilution of 1:1 with a TAN content of 1.15 kg N /m3.
appl_rate	m3 /ha	Application rate, mean volume of slurry applied on a ha per deployment.

4.3 Technical parameters

Parameter	Value	Unit	Description
norm_er	0.5	-	Standard emission of 50% of the applied TAN calculated based on an equation published by Menzi et al (1998) using a TAN standard of 1.15 kg /m3 for an 1:1 dilution, with application rate (AR) standard of 30 m3 /ha and average swiss meteorological conditions (T=12 C, humitity=70%): ((19.41 * TAN_standard + 4.2 * 1.102 - 9.51) * (0.0214 * ARstandard + 0.36) / (AR_standard * TAN-standard)))

4.4 Output

Parameter	Unit	Formula

TAN_content	-	TAN content of the slurry compared to the emission rate occuring with a standard application rate of 30 m3 and a TAN content of 1.15 kg N /m3.
		
		if(In(dilution_parts_water) > 0){
		2.3×(1/(In(dilution_parts_water)+1))
		}else{
		ERR "dilution_parts_water hast to be Greater tan zero!";
		}

c_app	-	Correction factor taking into account the slurry application rate per ha and the TAN content of the slurry. if((In(appl_rate) × Out(TAN_content)) > 0){ (((19.41 × Out(TAN_content) + 4.2 × 1.102 - 9.51) × (In(appl_rate) × 0.0214 + 0.36)) / (In(appl_rate) × Out(TAN_content)) - Tech(norm_er)); }else{ return 1; }

4.5 Detailed process description

This process computes the correction factor as a function of the application rate and the TAN content of the slurry. The equation has been described by Menzi et al. (1998). The correction factor is calculated based on the slurry application rate per ha and the TAN content of the slurry compared to the emission rate occurring with a standard application rate of 30 m3 and a TAN content of 1.15 kg N / m3.

4.5.1 References:

Menzi H, Katz, P E, Fahrni M, Neftel A, Frick R 1998. A simple empirical model based on regression analysis to estimate ammonia emissions after manure application. Atmospheric Environment 32: 301-307.

5 Application::Slurry::Cseason

Agrammon Group – 13-11-09

5.1 Short description

Correction factor of the standard emission rate of the season for slurry application.

5.2 Input parameters

Parameter	Unit	Description
appl_summer	%	Share of slurry applied June to August (in %).
appl_autumn_winter_spring	%	Share of slurry applied September to May.

5.3 Technical parameters

Parameter	Value	Unit	Description
c_summer	0.15	-	Correction factor for the application of slurry in summer (June to August): Model calculation according to the model of Katz (Menzi et al. 1997b) with meteorological data from Liebefeld 1993-2002: average from March to November 12°C, 70% relative air humidity, 1.15 kg/m3 TAN, 30 m3/ha resulting in a loss of 50.6% TAN; summer 17.8°C resulting in a loss of 56.7% TAN (+12%). Value chosen for cal-culation: +15%
c_autumn_winter_spring	-0.05	-	Correction factor for the application of slurry in autumn, winter and spring (Sept to May): Model calculation according to the model of Katz (Menzi et al. 1997b) with meteorological data from Liebefeld 1993-2002: average from March to November 12°C, 70% relative air humidity, 1.15 kg/m3 TAN, 30 m3/ha resulting in a loss of 50.6% TAN; spring/autumn/winter 9°C resulting in a loss of 48.1% TAN (-4.8%). Value chosen for calculation: -5%

5.4 Output

Parameter	Unit	Formula

appl_autumn_winter_spring	-	.
		
		 if((In(appl_autumn_winter_spring) ≤100) && (In(appl_autumn_winter_spring) ≥ 0)){
		 return (In(appl_autumn_winter_spring)/100);
		 }else{
		 ERR "Share of slurry applied September to May, not between 0 and 100%\n";
		 return (In(appl_autumn_winter_spring)/100);
		 };

appl_summer	-	.
		
		 if((In(appl_summer) ≤ 100) && (In(appl_summer) ≥ 0)) {
		 return (In(appl_summer)/100);
		 }else{
		 ERR "Share of slurry applied June to August, not between 0 and 100%\n";
		 return (In(appl_summer)/100);
		 };

c_season	-	Correction factor of the standard emission rate depending on season of application.
		
		if((In(appl_summer)+In(appl_autumn_winter_spring)) == 100){
		return (1 + (Out(appl_summer) × Tech(c_summer) +
		Out(appl_autumn_winter_spring) × Tech(c_autumn_winter_spring)));
		}
		else{
		ERR "Sum of \"appl_summer\" and \"appl_autumn_winter_spring\" not equal 100% !\n";
		return (1 + (Out(appl_summer) × Tech(c_summer) +
		Out(appl_autumn_winter_spring) × Tech(c_autumn_winter_spring)));
		}

5.5 Detailed process description

This process computes the correction factor for the seasons the slurry is applied.

5.5.1 References:

Menzi H, Frick R, Kaufmann R 1997. Ammoniak-Emissionen in der Schweiz: Ausmass und technische Beurteilung des Reduktionspotentials. Eidgenössische Forschungsanstalt für Agrarökologie und Landbau, Zürich-Reckenholz. 107pp.

Frick R, Menzi H 1997. Hofdüngeranwendung: Wie Ammoniakverluste vermindern? Auch einfache Massnahmen wirken. FAT Bericht Nr. 496.

6 Application::Slurry::Csoft

Agrammon Group – 13-11-09

6.1 Short description

Correction factor of the standard emission rate if different kind of "soft measures" are respected/applied.

6.2 Input parameters

Parameter	Unit	Description
appl_evening	%	Share of slurry applied in the evening after 18:00.
appl_hotdays	-	Proportion of slurry applied on hot days. Possible values: `never`, `rarely`, `sometimes`, `frequently`

6.3 Technical parameters

Parameter	Value	Unit	Description
c_evening	-0.2	-	Correction factor of the emission rate if slurry is applied in the evening (after 18h)(Menzi et al 1997; Frick and Menzi 1997). Assumption based on a single experiment with an application after 18h in August at a temperature of ¿20°C: reduction of the emission by 38%, the reduction of the emission averaged over the whole year is only 50%, i.e. -0.2 The correction is omitted for solid manure since infiltration into soil does not occur.
c_hotdays_frequently	0.1	-	Correction factor of the emission rate if slurry is applied frequently on hot days. Loss calculated according to the model of Katz (Menzi et al. 1997b) at 17°C (i.e. +5°C) compared to the reference temperature of 12°C (other parameters: 70% relative air humidity, 1.15 kg/m3 TAN, 30 m3/ha) resulting in a loss of 19.22 kg N/ha at 17 °C and 55.7% TAN, respectively (compared to 17.45 kg N/ha and 50.6% TAN at 12°C, respectively) which corresponds to an increase of 10.1% (rounded to 10%).
c_hotdays_sometimes	0.0	-	Correction factor of the emission rate if slurry is applied sometimes on hot days (estimation based on Menzi et al (1997)).
c_hotdays_rarely	-0.1	-	Correction factor of the emission rate if slurry is applied rarely on hot days (estimation based on Menzi et al (1997)).
c_hotdays_never	-0.2	-	Correction factor of the emission rate if slurry is applied never on hot days (estimation based on Menzi et al (1997)).

6.4 Output

Parameter	Unit	Formula

c_hotdays	-	Correction factor of the emission rate if slurry is applied on hot days.
		
		my $key = "c_hotdays_" . In(appl_hotdays);
		return Tech($key);

c_soft	-	Correction factor of the emission rate if slurry is applied by considering different kinds of "soft measures".
		
		if((In(appl_evening) ≤ 100) && (In(appl_evening)≥0)) {
		return (1 + ((In(appl_evening)/100) × Tech(c_evening) + Out(c_hotdays)));
		} else {
		ERR "Share of slurry applied in the evening after 18:00, not between 0 and 100%\n";
		return (1 + ((In(appl_evening)/100) × Tech(c_evening) + Out(c_hotdays)));
		};

6.5 Detailed process description

This process computes the correction factor if different soft measures for slurry application are respected.

6.5.1 References:

Menzi H, Frick R, Kaufmann R 1997. Ammoniak-Emissionen in der Schweiz: Ausmass und technische Beurteilung des Reduktionspotentials. Eidgenössische Forschungsanstalt für Agrarökologie und Landbau, Zürich-Reckenholz. 107pp.

Frick R, Menzi H 1997. Hofdüngeranwendung: Wie Ammoniakverluste vermindern? Auch einfache Massnahmen wirken. FAT Bericht Nr. 496.

7 Application::Slurry::Ctech

Agrammon Group – 13-11-09

7.1 Short description

Computes the correction factor depending on the slurry application technology used.

7.2 Input parameters

Parameter	Unit	Description
share_splash_plate	%	Share of slurry applied with splash plate.
share_trailing_hose	%	Share of slurry applied with trailing hose.
share_trailing_shoe	%	Share of slurry applied with trailing shoes.
share_shallow_injection	%	Share of slurry applied with shallow injection.
share_deep_injection	%	Share of slurry applied with deep injection.

7.3 Technical parameters

Parameter	Value	Unit	Description
red_splash_plate	0.0	-	There is no reduction for broadcasting with splash plate as to this way of applying slurry all the other methods are compared to.
red_trailing_hose	-0.3	-	Reduction efficiency as compared to broadcasting applying trailing hose. Adopted from UNECE (2007), Frick and Menzi (1997) and Menzi et al. (1997).
red_trailing_shoe	-0.5	-	Reduction efficiency as compared to broadcasting applying trailing shoe. Adopted from UNECE (2007), Frick and Menzi (1997) and Menzi et al. (1997).
red_shallow_injection	-0.7	-	Reduction efficiency as compared to broadcasting applying shallow injection. Adopted from UNECE (2007), Frick and Menzi (1997) and Menzi et al. (1997).
red_deep_injection	-0.8	-	Reduction efficiency as compared to broadcasting applying deep injection. Adopted from UNECE(2007), Frick and Menzi (1997) and Menzi et al. (1997).

7.4 Output

Parameter	Unit	Formula

share_shallow_injection	-	Share
		
		if((In(share_shallow_injection) $\leq$ 100) && (In(share_shallow_injection) $\geq$ 0)) {
		return (In(share_shallow_injection)/100);
		}else{
		ERR "Share of slurry applied with shallow injection, not between 0 and 100%\n";
		return (In(share_shallow_injection)/100);
		};

share_deep_injection	-	Share
		
		if((In(share_deep_injection) $\leq$ 100) && (In(share_deep_injection) $\geq$ 0)) {
		return (In(share_deep_injection)/100);
		}else{
		ERR "Share of slurry applied with deep injection, not between 0 and 100%\n";
		return (In(share_deep_injection)/100);
		};

share_splash_plate	-	Share
		
		if((In(share_splash_plate) ≤ 100) && (In(share_splash_plate) ≥ 0)){
		return (In(share_splash_plate)/100);
		}else{
		ERR ”Share of slurry applied with splash plate, not between 0 and 100%\n”;
		return (In(share_splash_plate)/100);
		};

share_trailing_shoe	-	Share
		
		if((In(share_trailing_shoe) ≤ 100) && (In(share_trailing_shoe) ≥ 0)){
		return (In(share_trailing_shoe)/100);
		}else{
		ERR ”Share of slurry applied with trailing shoes, not between 0 and 100%\n”;
		return (In(share_trailing_shoe)/100);
		};

c_tech	-	Reduction factor for the emission due to the used application technology as compared to broadcasting.
		
		if((Out(share_deep_injection) +
		Out(share_shallow_injection) +
		Out(share_trailing_shoe) +
		Out(share_trailing_hose) +
		Out(share_splash_plate)
		) == 1)
		{
		return 1 + (Out(share_deep_injection) × Tech(red_deep_injection) +
		Out(share_shallow_injection) × Tech(red_shallow_injection) +
		Out(share_trailing_shoe) × Tech(red_trailing_shoe) +
		Out(share_trailing_hose) × Tech(red_trailing_hose) +
		Out(share_splash_plate) × Tech(red_splash_plate)
		);
		}
		else{
		ERR ”Sum of used technics used for Slurry Application not 100% !\n”;
		return 1 + (Out(share_deep_injection) × Tech(red_deep_injection) +
		Out(share_shallow_injection) × Tech(red_shallow_injection) +
		Out(share_trailing_shoe) × Tech(red_trailing_shoe) +
		Out(share_trailing_hose) × Tech(red_trailing_hose) +
		Out(share_splash_plate) × Tech(red_splash_plate)
		);
		}

share_trailing_hose	-	Share
		
		if((In(share_trailing_hose) ≤ 100) && (In(share_trailing_hose) ≥ 0))
		{
		return (In(share_trailing_hose)/100);
		}else{
		ERR ”Share of slurry applied with trailing hose, not between 0 and 100%\n”;
		return (In(share_trailing_hose)/100);
		};

7.5 Detailed process description

This process computes the correction factor according to the technology used for the slurry application.

7.5.1 References:

UNECE 2007. Guidance document on control techniques for preventing and abating emissions of ammonia. UNECE executive body for the convention on long-range transboundary air pollution, Working Group on Strategies and Review, EB.AIR/WH.5/2007/13/ 16 July 2007, Genf. 35p.

Frick R, Menzi H 1997. Hofdüngeranwendung: Wie Ammoniakverluste vermindern? Auch einfache Massnahmen wirken. FAT Bericht 496.

Menzi H, Frick R, Kaufmann R 1997. Ammoniak-Emissionen in der Schweiz: Ausmass und technische Beurteilung des Reduktionspotentials. Eidgenössische Forschungsanstalt für Agrarökologie und Landbau, Zürich-Reckenholz. 107pp.

8 Application::SolidManure

Agrammon Group – 13-11-09

8.1 Short description

Computes the annual NH3 emission from solid manure application.

Attention: simplified model based on total N output from storage!!!

8.2 Input parameters

8.3 Technical parameters

8.4 Output

Parameter	Unit	Formula
n_fromsolid	kg N /a	N flux out of solid manure application. Val(n_into_application_manure, ::Storage) - Out(nh3_nsolid);
nh3_nsolid	kg N /a	NH3 emission from solid manure application. Val(nh3_nsolid_dairycows_cattle_pigs, SolidManure::Solid) + Val(nh3_nsolid_horses_otherequides_smallruminants, SolidManure::Solid) + Val(nh3_npoultry, SolidManure::Poultry);

8.5 Detailed process description

This process computes the annual average NH3 emission from solid manure application (liquid/solid and deep litter). The standard emission factor is corrected according to the TAN content and the application rate, the application technology, the crops to which the manure is applied, respected soft measures during application and the application season, the time lag between application and incorporation, the incorporation technology used, and the proportion of solid manure that is applied on hot days.

8.5.1 References:

Menzi H, Keller M, Katz P, Fahrni M, Neftel A 1997. Ammoniakverluste nach der Anwendung von Mist. Agrarforschung 4:328-331.

Menzi H, Katz P, Frick R, Fahrni M, Keller M 1997: Ammonia emissions following the application of solid manure to grassland. In: Jarvis S.C. and Pain B.F. (Eds.): "Nitrogen Emissions from Grassland", CAB, 265-274.

9 Application::SolidManure::CincorpTime

Agrammon Group – 13-11-09

9.1 Short description

Correction factor taking into account the time lag between application and incorporation of the solid manure.

9.2 Input parameters

Parameter	Unit	Description
incorp_lw1h	%	Share of incorporated solid manure within 1 hour.
incorp_lw4h	%	Share of incorporated solid manure within 4 hours.
incorp_lw8h	%	Share of incorporated solid manure within 8 hours.
incorp_lw1d	%	Share of incorporated solid manure within 1 day.
incorp_lw3d	%	Share of incorporated solid manure within 3 days.
incorp_gt3d	%	Share of incorporated solid manure after 3 days.
incorp_none	%	Share of solid manure not incorporated.

9.3 Technical parameters

9.4 Output

Parameter	Unit	Formula

incorp_lw1d	-	Share of incorporated solid manure within 1 day.
		
		if((In(incorp_lw1d) ≤ 100) && (In(incorp_lw1d) ≥ 0)){
		return (In(incorp_lw1d)/100)
		} else {
		ERR "Share of solid manure incorporated within 1 day, not between 0 and 100%\n";
		return (In(incorp_lw1d)/100);
		};

incorp_lw3d	-	Share of incorporated solid manure within 3 days.
		
		if((In(incorp_lw3d) ≤ 100) && (In(incorp_lw3d) ≥ 0)){
		return (In(incorp_lw3d)/100)
		} else {
		ERR "Share of solid manure incorporated within 3 days, not between 0 and 100%\n";
		return (In(incorp_lw3d)/100);
		};

incorp_none	-	Share of not-incorporated solid manure.
		
		if((In(incorp_none) ≤ 100) && (In(incorp_none) ≥ 0)){
		return (In(incorp_none)/100)
		} else {
		ERR "Share of solid manure not incorporate, not between 0 and 100%\n";
		return (In(incorp_none)/100);
		};

incorp_lw4h	-	Share of incorporated solid manure within 4 hour.
		
		if((In(incorp_lw4h) $\leq$ 100) && (In(incorp_lw4h) $\geq$ 0)){
		return (In(incorp_lw4h)/100)
		} else {
		ERR "Share of solid manure incorporated within 4 hours, not between 0 and 100%\n";
		return (In(incorp_lw4h)/100);
		};

incorp_lw1h	-	Share of incorporated solid manure within 1 hour.
		
		if((In(incorp_lw1h) $\leq$ 100) && (In(incorp_lw1h) $\geq$ 0)) {
		return (In(incorp_lw1h)/100)
		} else {
		ERR "Share of solid manure incorporated within 1 hour, not between 0 and 100%\n";
		return (In(incorp_lw1h)/100);
		};

incorp_lw8h	-	Share of incorporated solid manure within 8 hour.
		
		if((In(incorp_lw8h) $\leq$ 100) && (In(incorp_lw8h) $\geq$ 0)){
		return (In(incorp_lw8h)/100)
		} else {
		ERR "Share of solid manure incorporated within 8 hour, not between 0 and 100%\n";
		return (In(incorp_lw8h)/100);
		};

incorp_gt3d	-	Share of incorporated solid manure after 3 days.
		
		if((In(incorp_gt3d) $\leq$ 100) && (In(incorp_gt3d) $\geq$ 0)){
		return (In(incorp_gt3d)/100)
		} else {
		ERR "Share of solid manure incorporated more than 3 days, not between 0 and 100%\n";
		return (In(incorp_gt3d)/100);
		};

9.5 Detailed process description

This process computes the correction factor for the time lag between application and incorporation of the solid manure (from all animal categories).

9.5.1 References:

Menzi H, Keller M, Katz P, Fahrni M, Neftel A 1997. Ammoniakverluste nach der Anwendung von Mist. Agrarforschung 4:328-331.

10 Application::SolidManure::Cseason

Agrammon Group – 13-11-09

10.1 Short description

Correction factor of the standard emission rate of the season for solid manure application.

10.2 Input parameters

Parameter	Unit	Description
appl_summer	%	Share of solid manure applied June to August (in %).
appl_autumn_winter_spring	%	Share of solid manure applied September to May (in %).

10.3 Technical parameters

Parameter	Value	Unit	Description
c_summer	0.15	-	Correction factor for the application of solid manure in summer (June to August): Model calculation according to the model of Katz (Menzi et al. 1997b) with meteorological data from Liebefeld 1993-2002: average from March to November 12°C, 70% relative air humidity, 1.15 kg/m3 TAN, 30 m3/ha resulting in a loss of 50.6% TAN; summer 17.8°C resulting in a loss of 56.7% TAN (+12%). Value chosen for cal-culation: +15%.
c_autumn_winter_spring	-0.05	-	Correction factor for the application of solid manure in autumn, winter and spring (Sept to May): Model calculation according to the model of Katz (Menzi et al. 1997b) with meteorological data from Liebefeld 1993-2002: average from March to November 12°C, 70% relative air humidity, 1.15 kg/m3 TAN, 30 m3/ha resulting in a loss of 50.6% TAN; spring/autumn/winter 9°C resulting in a loss of 48.1% TAN (-4.8%). Value chosen for calculation: -5%.

10.4 Output

Parameter	Unit	Formula

appl_autumn_winter_spring	-	.
		
		if((In(appl_autumn_winter_spring) ≤100) && (In(appl_autumn_winter_spring) ≥ 0)){
		return (In(appl_autumn_winter_spring)/100);
		}else{
		ERR "Share of slurry applied September to May, not between 0 and 100%\n";
		return (In(appl_autumn_winter_spring)/100);
		};

appl_summer	-	.
		
		if((In(appl_summer) ≤ 100) && (In(appl_summer) ≥ 0)){
		return (In(appl_summer)/100);
		}else{
		ERR "Share of slurry applied June to August, not between 0 and 100%\n";
		return (In(appl_summer)/100);
		};

c_season	-	Correction factor of the standard emission rate depending on season of application.
		
		if((In(appl_summer)+In(appl_autumn_winter_spring)) == 100){
		(1 + (Out(appl_summer) × Tech(c_summer) +
		Out(appl_autumn_winter_spring) × Tech(c_autumn_winter_spring)));
		}
		else{
		ERR "Sum of \"appl_summer\" and \"appl_autumn_winter_spring\" not equal 100% !\n";
		(1 + (Out(appl_summer) × Tech(c_summer) +
		Out(appl_autumn_winter_spring) × Tech(c_autumn_winter_spring)));
		}

10.5 Detailed process description

This process computes the correction factor for the seasons the solid manure is applied.

10.5.1 References:

Menzi H, Frick R, Kaufmann R 1997. Ammoniak-Emissionen in der Schweiz: Ausmass und technische Beurteilung des Reduktionspotentials. Eidgenössische Forschungsanstalt für Agrarökologie und Landbau, Zürich-Reckenholz. 107pp.

Frick R, Menzi H 1997. Hofdüngeranwendung: Wie Ammoniakverluste vermindern? Auch einfache Massnahmen wirken. FAT Bericht Nr. 496.

11 Application::SolidManure::Poultry

Agrammon Group – 13-11-09

11.1 Short description

Computes the annual NH3 emission from poultry manure application.

11.2 Input parameters

11.3 Technical parameters

Parameter	Value	Unit	Description
er_App_manure_layers-_growers_other_poultry	0.3	-	Emission rate for manure application. The average rate has been derived from Frick et al. (1996) and Menzi et al. (1997). The value is based on the average emissions from diffrent Swiss experiments. Emission based on TAN of slurry.
er_App_manure_turkeys-_broilers	0.65	-	Emission rate for manure application. The average rate has been derived from Frick et al. (1996) and Menzi et al. (1997). The value is based on the average emissions from diffrent Swiss experiments. Emission based on TAN of slurry.

11.4 Output

Parameter	Unit	Formula
nh3_npoultry_turkeys-_broilers	kg N /a	NH3 emission from solid manure application. Tech(er_App_manure_turkeys_broilers) × Val(tan_into_application_turkeys_broilers, ::Storage::SolidManure::Poultry) × Val(c_incorp_time, Poultry::CincorpTime) × Val(c_season, Cseason);
n_frompoultry	kg N /a	N flux out of solid manure application. Val(n_into_application, ::Storage::SolidManure::Poultry) - Out(nh3_npoultry);
nh3_npoultry_layers-_growers_other_poultry	kg N /a	NH3 emission from solid manure application. Tech(er_App_manure_layers_growers_other_poultry) × Val(tan_into_application_layers_growers_other_poultry, ::Storage::SolidManure::Poultry) × Val(c_incorp_time, Poultry::CincorpTime) × Val(c_season, Cseason);
nh3_npoultry	kg N /a	NH3 emission from solid manure application. Out(nh3_npoultry_layers_growers_other_poultry) + Out(nh3_npoultry_turkeys_broilers);

11.5 Detailed process description

This process computes the annual average NH3 emission from poultry manure application. The standard emission factor is corrected according to the TAN content and the application rate, the application technology, the crops to which the manure is applied, respected soft measures during application and the application season, the time lag between application and incorporation, the incorporation technology used, and the proportion of solid manure that is applied on hot days.

The correction factor are based on the same input parameters as the application for solid manure.

11.5.1 References:

Menzi H, Keller M, Katz P, Fahrni M, Neftel A 1997. Ammoniakverluste nach der Anwendung von Mist. Agrarforschung 4:328-331.

Menzi H, Katz P, Frick R, Fahrni M, Keller M 1997: Ammonia emissions following the application of solid manure to grassland. In: Jarvis S.C. and Pain B.F. (Eds.): "Nitrogen Emissions from Grassland", CAB, 265-274.

12 Application::SolidManure::Poultry::CincorpTime

Agrammon Group – 13-11-09

12.1 Short description

Correction factor taking into account the time lag between application and incorporation of the poultry manure.

12.2 Input parameters

12.3 Technical parameters

Parameter	Value	Unit	Description
eff_inc_lw1h	-0.95	-	Reduction due to incorporation of solid manure within 1 hour. UNECE (2007).
eff_inc_lw4h	-0.8	-	Reduction due to incorporation of solid manure within 4 hours. Empirical estimate deduced from UNECE (2007). Mean value between the category incorporation within 1 hour and incorporation within 8 hours.
eff_inc_lw8h	-0.7	-	Reduction due to incorporation of solid manure within 8 hours. Values adapted from UNECE (2007) (category Incorporation by plough within 12 h)
eff_inc_lw1d	-0.55	-	Reduction due to incorporation of solid manure within 1 day. Values adapted from UNECE (2007) Empirical estimate deduced from Menzi et al. (1997).
eff_inc_lw3d	-0.3	-	Reduction due to incorporation of solid manure within 3 days. Empirical estimate deduced from Menzi et al. (1997).
eff_inc_gt3d	-0.1	-	Reduction due to incorporation of solid manure after 3 days Empirical estimate deduced from Menzi et al. (1997).
eff_inc_none	0.0	-	Basis with no incorporation of solid manure.

12.4 Output

Parameter	Unit	Formula

c_incorp_time	-	Correction factor taking into account the time lag between application and incorporation of the solid manure.
		
		if((Val('incorp_lw1h','..::CincorpTime') +
		Val('incorp_lw4h','..::CincorpTime') +
		Val('incorp_lw8h','..::CincorpTime') +
		Val('incorp_lw1d','..::CincorpTime') +
		Val('incorp_lw3d','..::CincorpTime') +
		Val('incorp_gt3d','..::CincorpTime') +
		Val('incorp_none','..::CincorpTime')
		) ≥ 0.999999
		&& (Val('incorp_lw1h','..::CincorpTime') +
		Val('incorp_lw4h','..::CincorpTime') +
		Val('incorp_lw8h','..::CincorpTime') +
		Val('incorp_lw1d','..::CincorpTime') +
		Val('incorp_lw3d','..::CincorpTime') +
		Val('incorp_gt3d','..::CincorpTime') +
		Val('incorp_none','..::CincorpTime')
		) ≤ 1.000001
		)
		{
		return 1 + (Val('incorp_lw1h','..::CincorpTime') × Tech('eff_inc_lw1h') +
		Val('incorp_lw4h','..::CincorpTime') × Tech('eff_inc_lw4h') +
		Val('incorp_lw8h','..::CincorpTime') × Tech('eff_inc_lw8h') +
		Val('incorp_lw1d','..::CincorpTime') × Tech('eff_inc_lw1d') +
		Val('incorp_lw3d','..::CincorpTime') × Tech('eff_inc_lw3d') +
		Val('incorp_gt3d','..::CincorpTime') × Tech('eff_inc_gt3d') +
		Val('incorp_none','..::CincorpTime') × Tech('eff_inc_none')
		);
		}
		else{
		ERR "Sum of incorporateion values not equal 100% !\n";
		return 1 + (Val('incorp_lw1h','..::CincorpTime') × Tech('eff_inc_lw1h') +
		Val('incorp_lw4h','..::CincorpTime') × Tech('eff_inc_lw4h') +
		Val('incorp_lw8h','..::CincorpTime') × Tech('eff_inc_lw8h') +
		Val('incorp_lw1d','..::CincorpTime') × Tech('eff_inc_lw1d') +
		Val('incorp_lw3d','..::CincorpTime') × Tech('eff_inc_lw3d') +
		Val('incorp_gt3d','..::CincorpTime') × Tech('eff_inc_gt3d') +
		Val('incorp_none','..::CincorpTime') × Tech('eff_inc_none')
		);
		}

12.5 Detailed process description

This process computes the correction factor for the time lag between application and incorporation of the poultry manure.

12.5.1 References:

Menzi H, Keller M, Katz P, Fahrni M, Neftel A 1997. Ammoniakverluste nach der Anwendung von Mist. Agrarforschung 4:328-331.

Menzi H, Katz P, Frick R, Fahrni M, Keller M 1997: Ammonia emissions following the application of solid manure to grassland. In: Jarvis S.C. and Pain B.F. (Eds.): "Nitrogen Emissions from Grassland", CAB, 265-274.

UNECE 2007. Guidance document on control techniques for preventing and abating emissions of ammonia. ECE/EB.AIR/WG.5/2007/13.

13 Application::SolidManure::Solid

Agrammon Group – 13-11-09

13.1 Short description

Computes the annual NH3 emission from solid manure application.
Attention: simplified model based on total N output from storage!!!

13.2 Input parameters

13.3 Technical parameters

Parameter	Value	Unit	Description
er_App_manure_dairycows-_cattle_pigs	0.8	-	Emission rate for manure application. The average rate has been derived from Frick et al. (1996) and Menzi et al. (1996). The value is based on the average emissions from diffrent Swiss experiments. Emission based on TAN of slurry.
er_App_manure-_horses_otherequides-_smallruminants	0.7	-	Emission rate for manure application. The average rate has been derived from Frick et al. (1996) and Menzi et al. (1996). The value is based on the average emissions from diffrent Swiss experiments. Emission based on TAN of slurry.

13.4 Output

Parameter	Unit	Formula
nh3_nsolid_horses-_otherequides-_smallruminants	kg N /a	NH3 emission from solid manure application. Tech(er_App_manure_horses_otherequides_smallruminants) × Val(tan_into_application_horses_otherequides_smallruminants, ::Storage::SolidManure::Solid) × Val(c_incorp_time, Solid::CincorpTime) × Val(c_season, Cseason);
nh3_nsolid_dairycows-_cattle_pigs	kg N /a	NH3 emission from solid manure application. Tech(er_App_manure_dairycows_cattle_pigs) × Val(tan_into_application_dairycows_cattle_pigs, ::Storage::SolidManure::Solid) × Val(c_incorp_time, Solid::CincorpTime) × Val(c_season, Cseason);

13.5 Detailed process description

This process computes the annual average NH3 emission from solid manure application (liquid/solid and deep litter). The standard emission factor is corrected according to the TAN content and the application rate, the application technology, the crops to which the manure is applied, respected soft measures during application and the application season, the time lag between application and incorporation, the incorporation technology used, and the proportion of solid manure that is applied on hot days.

13.5.1 References:

Menzi H, Keller M, Katz P, Fahrni M, Neftel A 1997. Ammoniakverluste nach der Anwendung von Mist. Agrarforschung 4:328-331.

Menzi H, Katz P, Frick R, Fahrni M, Keller M 1997: Ammonia emissions following the application of solid manure to grassland. In: Jarvis S.C. and Pain B.F. (Eds.): "Nitrogen Emissions from Grassland", CAB, 265-274.

14 Application::SolidManure::Solid::CincorpTime

Agrammon Group – 13-11-09

14.1 Short description

Correction factor taking into account the time lag between application and incorporation of the solid manure.

14.2 Input parameters

14.3 Technical parameters

Parameter	Value	Unit	Description
eff_inc_lw1h	-0.9	-	Reduction due to incorporation of solid manure within 1 hour. UNECE (2007).
eff_inc_lw4h	-0.7	-	Reduction due to incorporation of solid manure within 4 hours. Empirical estimate deduced from UNECE (2007). Mean value between the category incorporation within 1 hour and incorporation within 8 hours.
eff_inc_lw8h	-0.5	-	Reduction due to incorporation of solid manure within 8 hours. Values adapted from UNECE (2007) (category Incorporation by plough within 12 h)
eff_inc_lw1d	-0.35	-	Reduction due to incorporation of solid manure within 1 day. Values adapted from UNECE (2007) Empirical estimate deduced from Menzi et al. (1997).
eff_inc_lw3d	-0.3	-	Reduction due to incorporation of solid manure within 3 days. Empirical estimate deduced from Menzi et al. (1997).
eff_inc_gt3d	-0.1	-	Reduction due to incorporation of solid manure after 3 days Empirical estimate deduced from Menzi et al. (1997).
eff_inc_none	0.0	-	Basis with no incorporation of solid manure.

14.4 Output

Parameter	Unit	Formula

c_incorp_time	-	Correction factor taking into account the time lag between application and incorporation of the solid manure.
		
		if((Val('incorp_lw1h','..::CincorpTime') +
		Val('incorp_lw4h','..::CincorpTime') +
		Val('incorp_lw8h','..::CincorpTime') +
		Val('incorp_lw1d','..::CincorpTime') +
		Val('incorp_lw3d','..::CincorpTime') +
		Val('incorp_gt3d','..::CincorpTime') +
		Val('incorp_none','..::CincorpTime')
		) ≥ 0.999999
		&& (Val('incorp_lw1h','..::CincorpTime') +
		Val('incorp_lw4h','..::CincorpTime') +
		Val('incorp_lw8h','..::CincorpTime') +
		Val('incorp_lw1d','..::CincorpTime') +
		Val('incorp_lw3d','..::CincorpTime') +
		Val('incorp_gt3d','..::CincorpTime') +
		Val('incorp_none','..::CincorpTime')
		) ≤ 1.000001
		)
		{
		return 1 + (Val('incorp_lw1h','..::CincorpTime') × Tech('eff_inc_lw1h') +
		Val('incorp_lw4h','..::CincorpTime') × Tech('eff_inc_lw4h') +
		Val('incorp_lw8h','..::CincorpTime') × Tech('eff_inc_lw8h') +
		Val('incorp_lw1d','..::CincorpTime') × Tech('eff_inc_lw1d') +
		Val('incorp_lw3d','..::CincorpTime') × Tech('eff_inc_lw3d') +
		Val('incorp_gt3d','..::CincorpTime') × Tech('eff_inc_gt3d') +
		Val('incorp_none','..::CincorpTime') × Tech('eff_inc_none')
		);
		}
		else{
		ERR "Sum of incorporateion values not equal 100% !\n";
		return 1 + (Val('incorp_lw1h','..::CincorpTime') × Tech('eff_inc_lw1h') +
		Val('incorp_lw4h','..::CincorpTime') × Tech('eff_inc_lw4h') +
		Val('incorp_lw8h','..::CincorpTime') × Tech('eff_inc_lw8h') +
		Val('incorp_lw1d','..::CincorpTime') × Tech('eff_inc_lw1d') +
		Val('incorp_lw3d','..::CincorpTime') × Tech('eff_inc_lw3d') +
		Val('incorp_gt3d','..::CincorpTime') × Tech('eff_inc_gt3d') +
		Val('incorp_none','..::CincorpTime') × Tech('eff_inc_none')
		);
		}

14.5 Detailed process description

This process computes the correction factor for the time lag between application and incorporation of the solid manure.

14.5.1 References:

Menzi H, Keller M, Katz P, Fahrni M, Neftel A 1997. Ammoniakverluste nach der Anwendung von Mist. Agrarforschung 4:328-331.

15 End

Agrammon Group – 13-11-09

15.1 Short description

Dummy Module marking the startpoint for the Model Parser

15.2 Input parameters

15.3 Technical parameters

15.4 Output

Parameter	Unit	Formula

15.5 Detailed process description

16 Livestock

Agrammon Group – 13-11-09

16.1 Short description

Collects the annual NH3 emission and the N flux for transfer into storage.

16.2 Input parameters

16.3 Technical parameters

16.4 Output

Parameter	Unit	Formula
nh3_ngrazing	kg N /a	Annual NH3 emission from all grazing areas and Poultry outdoor activities. Sum(nh3_ngrazing, Livestock::OtherCattle::Grazing) + Sum(nh3_ngrazing, Livestock::DairyCow::Grazing) + Sum(nh3_ngrazing, Livestock::Pig::Grazing) + Sum(nh3_ngrazing, Livestock::FatteningPigs::Grazing) + Sum(nh3_ngrazing, Livestock::Equides::Grazing) + Sum(nh3_ngrazing, Livestock::SmallRuminants::Grazing) + Sum(nh3_nfree_range, Livestock::Poultry::Outdoor);
tan_into_storage_poultry-_turkeys_broilers	kg N /a	Annual N flux (poulty manure) as TAN from housing and yard into the storage from poultry. Sum(tan_from_poultry_turkeys_broilers, Livestock::Poultry);
n_remain_pasture	kg N /a	Annual N remaining on pasture from all grazing areas. Sum(n_remain_pasture, Livestock::OtherCattle::Grazing) + Sum(n_remain_pasture, Livestock::DairyCow::Grazing) + Sum(n_remain_pasture, Livestock::Pig::Grazing) + Sum(n_remain_pasture, Livestock::FatteningPigs::Grazing) + Sum(n_remain_pasture, Livestock::Equides::Grazing) + Sum(n_remain_pasture, Livestock::SmallRuminants::Grazing) + Sum(n_remain_free_range, Livestock::Poultry::Outdoor);
n_into_storage_solid-_dairycows_cattle_pigs	kg N /a	Annual N flux (solid share) from housing and yard into the storage from all animals besides poultry. Sum(n_solid_from_cattle, Livestock::OtherCattle) + Sum(n_solid_from_dairycow, Livestock::DairyCow) + Sum(n_solid_from_pig, Livestock::Pig) + Sum(n_solid_from_fattening_pig, Livestock::FatteningPigs);
n_into_storage_liquid_pigs	kg N /a	Annual N flux (liquid share) from pigs housing into the storage (used for calculation of the ef of mixed storage units). Sum(n_liquid_from_pig, Livestock::Pig) + Sum(n_liquid_from_fattening_pig, Livestock::FatteningPigs);
n_into_storage_poultry-_turkeys_broilers	kg N /a	Annual N flux from poultry (broilers, turkeys) into the storage. Sum(n_from_poultry_turkeys_broilers, Livestock::Poultry);
tan_into_storage_solid-_dairycows_cattle	kg N /a	Annual N flux (solid share) as TAN from housing and yard into the storage from all animals besides poultry. Sum(tan_solid_from_cattle, Livestock::OtherCattle) + Sum(tan_solid_from_dairycow, Livestock::DairyCow);
tan_into_storage_solid_pigs	kg N /a	Annual N flux (solid share) as TAN from housing and yard into the storage from pigs. Sum(tan_solid_from_pig, Livestock::Pig) + Sum(tan_solid_from_fattening_pig, Livestock::FatteningPigs);

n_into_storage_solid	kg N /a	Annual N flux (solid share) from housing and yard into the storage from all animals besides poultry. Sum(n_solid_from_cattle, Livestock::OtherCattle) + Sum(n_solid_from_dairycow, Livestock::DairyCow) + Sum(n_solid_from_pig, Livestock::Pig) + Sum(n_solid_from_fattening_pig, Livestock::FatteningPigs) + Sum(n_solid_from_equides, Livestock::Equides) + Sum(n_solid_from_other, Livestock::SmallRuminants) + Sum(n_from_poultry, Livestock::Poultry);
nh3_nhousing_and_yard	kg N /a	Annual NH3 emission from all housings and yards. Sum(nh3_nhousing, Livestock::OtherCattle::Housing) + Sum(nh3_nhousing, Livestock::DairyCow::Housing) + Sum(nh3_nhousing, Livestock::SmallRuminants::Housing) + Sum(nh3_nhousing, Livestock::Pig::Housing) + Sum(nh3_nhousing, Livestock::FatteningPigs::Housing) + Sum(nh3_nhousing, Livestock::Equides::Housing) + Sum(nh3_nhousing, Livestock::Poultry::Housing) + Sum(nh3_nyard, Livestock::OtherCattle::Yard) + Sum(nh3_nyard, Livestock::Equides::Yard) + Sum(nh3_nyard, Livestock::DairyCow::Yard);
n_into_storage_liquid	kg N /a	Annual N flux (liquid share) from housing and yard into the storage from all animal besides poultry. Sum(n_liquid_from_cattle, Livestock::OtherCattle) + Sum(n_liquid_from_dairycow, Livestock::DairyCow) + Sum(n_liquid_from_pig, Livestock::Pig) + Sum(n_liquid_from_fattening_pig, Livestock::FatteningPigs) + Sum(n_liquid_from_equides, Livestock::Equides) + Sum(n_liquid_from_other, Livestock::SmallRuminants);
tan_into_storage_solid-_horses_otherequides-_smallruminants	kg N /a	Annual N flux (solid share) as TAN from housing and yard into the storage from all animals besides poultry. Sum(tan_solid_from_equides, Livestock::Equides) + Sum(tan_solid_from_other, Livestock::SmallRuminants);
n_into_storage	kg N /a	Annual N flux (liquid and solid share) from housing and yard into the storage from all animals. Sum(n_from_cattle, Livestock::OtherCattle) + Sum(n_from_dairycow, Livestock::DairyCow) + Sum(n_from_pig, Livestock::Pig) + Sum(n_from_fattening_pig, Livestock::FatteningPigs) + Sum(n_from_equides, Livestock::Equides) + Sum(n_from_other, Livestock::SmallRuminants) + Sum(n_from_poultry, Livestock::Poultry);
nh3_nyard	kg N /a	Annual NH3 emission from all yards. Sum(nh3_nyard, Livestock::OtherCattle::Yard) + Sum(nh3_nyard, Livestock::Equides::Yard) + Sum(nh3_nyard, Livestock::DairyCow::Yard);
n_into_storage_solid-_horses_otherequides-_smallruminants	kg N /a	Annual N flux (solid share) from housing and yard into the storage from all animals besides poultry. Sum(n_solid_from_equides, Livestock::Equides) + Sum(n_solid_from_other, Livestock::SmallRuminants);
nh3_nhousing	kg N /a	Annual NH3 emission from all housings. Sum(nh3_nhousing, Livestock::OtherCattle::Housing) + Sum(nh3_nhousing, Livestock::DairyCow::Housing) + Sum(nh3_nhousing, Livestock::SmallRuminants::Housing) + Sum(nh3_nhousing, Livestock::Pig::Housing) + Sum(nh3_nhousing, Livestock::FatteningPigs::Housing) + Sum(nh3_nhousing, Livestock::Equides::Housing) + Sum(nh3_nhousing, Livestock::Poultry::Housing);

n_excretion	kg N /a	Total annual N excreted by all animals. Sum(n_excretion, Livestock::OtherCattle) + Sum(n_excretion, Livestock::DairyCow) + Sum(n_excretion, Livestock::Pig) + Sum(n_excretion, Livestock::FatteningPigs) + Sum(n_excretion, Livestock::Equides) + Sum(n_excretion, Livestock::SmallRuminants) + Sum(n_excretion, Livestock::Poultry);
tan_into_storage_poultry	kg N /a	Annual N flux (poulty manure) as TAN from housing and yard into the storage from poultry. Sum(tan_from_poultry, Livestock::Poultry);
tan_to_grazing	kg TAN /a	Annual N remaining on pasture from all grazing areas. Sum(n_sol_into_grazing, Livestock::OtherCattle::Grazing) + Sum(n_sol_into_grazing, Livestock::DairyCow::Grazing) + Sum(n_sol_into_grazing, Livestock::Pig::Grazing) + Sum(n_sol_into_grazing, Livestock::FatteningPigs::Grazing) + Sum(n_sol_into_grazing, Livestock::Equides::Grazing) + Sum(n_sol_into_grazing, Livestock::SmallRuminants::Grazing) + Sum(tan_excr_free_range, Livestock::Poultry::Outdoor);
tan_into_storage_solid	kg N /a	Annual N flux (solid share) as TAN from housing and yard into the storage from all animals besides poultry. Sum(tan_solid_from_cattle, Livestock::OtherCattle) + Sum(tan_solid_from_dairycow, Livestock::DairyCow) + Sum(tan_solid_from_pig, Livestock::Pig) + Sum(tan_solid_from_fattening_pig, Livestock::FatteningPigs) + Sum(tan_solid_from_equides, Livestock::Equides) + Sum(tan_solid_from_other, Livestock::SmallRuminants) + Sum(tan_from_poultry, Livestock::Poultry);
nh3_nlivestock	kg N /a	Annual NH3 emission from livestock from all animals. Sum(nh3_ncattle, Livestock::OtherCattle) + Sum(nh3_ndairycow, Livestock::DairyCow) + Sum(nh3_nother, Livestock::SmallRuminants) + Sum(nh3_npig, Livestock::Pig) + Sum(nh3_nfattening_pig, Livestock::FatteningPigs) + Sum(nh3_nequides, Livestock::Equides) + Sum(nh3_npoultry, Livestock::Poultry);
tan_excretion	kg TAN /a	Total annual TAN excreted by all animals. Sum(n_sol_excretion, Livestock::OtherCattle::Excretion) + Sum(n_sol_excretion, Livestock::DairyCow::Excretion) + Sum(n_sol_excretion, Livestock::Pig::Excretion) + Sum(n_sol_excretion, Livestock::FatteningPigs::Excretion) + Sum(n_sol_excretion, Livestock::Equides::Excretion) + Sum(n_sol_excretion, Livestock::SmallRuminants::Excretion) + Sum(n_sol_excretion, Livestock::Poultry::Excretion);
n_into_storage_poultry-_layers_growers_other-_poultry	kg N /a	Annual N flux from poultry (layers, growers, other poultry) into the storage. Sum(n_from_poultry_layers_growers_other_poultry, Live-stock::Poultry);
tan_into_storage	kg TAN /a	Annual TAN flux as TAN from housing and yard into the storage from all animals besides poultry. Sum(tan_from_cattle, Livestock::OtherCattle) + Sum(tan_from_dairycow, Livestock::DairyCow) + Sum(tan_from_pig, Livestock::Pig) + Sum(tan_from_fattening_pig, Livestock::FatteningPigs) + Sum(tan_from_equides, Livestock::Equides) + Sum(tan_from_other, Livestock::SmallRuminants) + Sum(tan_from_poultry, Livestock::Poultry);
n_into_storage_poultry	kg N /a	Annual N flux from poultry into the storage. Sum(n_from_poultry, Livestock::Poultry);

tan_into_storage_liquid_pigs	kg N /a	Annual N flux (liquid share) as TAN from pigs housing into the storage (used for calculation of the ef of mixed storage units). Sum(tan_liquid_from_pig, Livestock::Pig) + Sum(tan_liquid_from_fattening_pig, Livestock::FatteningPigs);
tan_into_storage_poultry-_layers_growers_other-_poultry	kg N /a	Annual N flux (poulty manure) as TAN from housing and yard into the storage from poultry. Sum(tan_from_poultry_layers_growers_other_poultry, Livestock::Poultry);
tan_into_storage_liquid	kg N /a	Annual N flux (liquid share) as TAN from housing and yard into the storage from all animals besides poultry. Sum(tan_liquid_from_cattle, Livestock::OtherCattle) + Sum(tan_liquid_from_dairycow, Livestock::DairyCow) + Sum(tan_liquid_from_pig, Livestock::Pig) + Sum(tan_liquid_from_fattening_pig, Livestock::FatteningPigs) + Sum(tan_liquid_from_equides, Livestock::Equides) + Sum(tan_liquid_from_other, Livestock::SmallRuminants);

16.5 Detailed process description

This process summarizes the annual NH3 emission from livestock (housing, yard and grazing) for all animal categories. Further it calculates the N flux into storage from housing and yard. The manure is splited in solid and liquid/slurry.

17 Livestock::DairyCow

Agrammon Group – 13-11-09

17.1 Short description

Collects the annual emission of NH3 and the N flux for dairy cows.

17.2 Input parameters

17.3 Technical parameters

17.4 Output

Parameter	Unit	Formula
tan_solid_from_dairycow	kg N /a	Annual N flux as TAN from dairy cows housing and yard, solid fraction. Val('tan_outhousing_solid', DairyCow::Housing) + Val('tan_outyard_solid', DairyCow::Yard);
tan_from_dairycow	kg N /a	Annual N flux as TAN from dairy cow housing and yard. Val(tan_outhousing, DairyCow::Housing) + Val(tan_outyard, DairyCow::Yard);
n_solid_from_dairycow	kg N /a	Annual N flux from dairy cows housing and yard, solid fraction. Val('n_outhousing_solid', DairyCow::Housing) + Val('n_outyard_solid', DairyCow::Yard);
n_from_dairycow	kg N /a	Annual N flux from dairy cows housing and yard. Val('n_outhousing', DairyCow::Housing) + Val('n_outyard', DairyCow::Yard);
nh3_ndairycow	kg N /a	Annual NH3 emission from dairy cows housing, yard and grazing (production). Val('nh3_nhousing', DairyCow::Housing) + Val('nh3_nyard', DairyCow::Yard) + Val('nh3_ngrazing', DairyCow::Grazing);
n_excretion	kg N /a	Annual N excreted by dairy cows. Val('n_excretion', DairyCow::Excretion);
tan_liquid_from_dairycow	kg N /a	Annual N flux as TAN from dairy cow housing and yard, liquid fraction. Val('tan_outhousing_liquid', DairyCow::Housing) + Val('tan_outyard_liquid', DairyCow::Yard);
n_liquid_from_dairycow	kg N /a	Annual N flux from dairy cows housing and yard, liquid fraction. Val('n_outhousing_liquid', DairyCow::Housing) + Val('n_outyard_liquid', DairyCow::Yard);

17.5 Detailed process description

This process summarizes the annual emission of NH3 for dairy cows from housing, yard and grazing. Further it summarizes the annual N flux from the housing to the storage for dairy cows.

18 Livestock::DairyCow::Excretion

Agrammon Group – 13-11-09

18.1 Short description

Computes the annual N excretion of a number of dairy cows as a function of the milk yield and the feed ration.

18.2 Input parameters

18.3 Technical parameters

18.4 Output

Parameter	Unit	Formula
dairy_cows	-	Number of dairy cows in barn. In('dairy_cows');
n_sol_excretion	kg N /a	Annual soluble N excreted by a specified number of animals. (Tech(share_Nsol) × Tech(standard_N_excretion) × Val(cmilk_yield, Excretion::CMilk) × In('dairy_cows')) + (Out(n_excretion) - Tech(standard_N_excretion)×In('dairy_cows') × Val(cmilk_yield, Excretion::CMilk)) × Tech(feed_influence_on_Nsol);
n_excretion_animal	kg N /a	Annual mean total N excreted per animal. Tech(standard_N_excretion) × Val(cmilk_yield, Excretion::CMilk) × Val(c_feed_ration, Excretion::CFeed);
n_excretion	kg N /a	Annual total N excreted by a specified number of animals. Tech(standard_N_excretion) × Val(cmilk_yield, Excretion::CMilk) × Val(c_feed_ration, Excretion::CFeed) × In('dairy_cows');

18.5 Detailed process description

This process calculates the annual N excretion (total N and Nsol (urea plus measured total ammoniacal nitrogen)) of a number of dairy cows as a function of the milk yield and the supplied feed ration. Nitrogen surpluses from increased nitrogen uptake are primarily excreted as Nsol in the urine. Eighty percent of the increased N excretion is therefore added to the Nsol fraction.

The standard N excretion was taken from the official Swiss fertilizer guidelines. These values were compiled on the basis of official feeding recommendations (RAP 1999) by a group of feeding experts under the lead of H. Menzi. Even though the methodology used is not documented in detail, it was well known to the authors of DYNAMO.

18.5.1 References:

Burgos SA, Robinson PH, Fadel JG, DePeters EJ 2005. Ammonia volatilization potential: Prediction of urinary urea nitrogen output on lactating dairy cows. Agriculture, Ecosystems and Environment 111:261-269.

Peterson SO, Sommer SG, Aaes O, Soegaard K 1998. Ammonia losses from urine and dung of grazing cattle: effect of N intake. Atmospheric environment 32:295-300.

RAP 1999. Fütterungsempfehlungen und Nährwerttabelle für Wiederkäuer. 4. überarbeitete Auflage, 327p, Landwirtschaftliche Lehrmittelzentrale, Zollikofen.

Flisch R, Sinaj S, Charles R, Richner W 2009. Grundlagen für die die Düngung im Acker- und Futterbau. Agrarforschung 16(2).

19 Livestock::DairyCow::Excretion::CConcentrates

Agrammon Group – 13-11-09

19.1 Short description

Computes the correction factor for the annual N excretion of a dairy cow as a function of the amount and type of concentrates used.

19.2 Input parameters

19.3 Technical parameters

19.4 Output

Parameter	Unit	Formula
c_concentrates_summer	-	Calculation of correction to exretions with 0.3, 0.5, 1, 2, 3, 4, 6 kg of concentrate (barley and wheat) per cow per day, taking into account the amount of roghage substituted by the concentrate (according to the energy content) and the relative differnce of the protein content of the roughage and the concentrate. Results used to calculate a regression for % modification of N excretion due to concentrate quantity summer. Standard for Summer = 1 kg animal-1 day-1. Tech(par_a_summer) + Tech(par_b_summer) × In('amount_summer');
c_concentrates_winter	-	Calculation of correction to exretions with 0.3, 0.5, 1, 2, 3, 4, 6 kg of concentrate (barley and wheat) per cow per day, taking into account the amount of roghage substituted by the concentrate (according to the energy content) and the relative differnce of the protein content of the roughage and the concentrate. Results used to calculate a regression for % modification of N excretion due to concentrate quantity summer. Standard for Winter = 2 kg animal-1 day-1. Tech(par_a_winter) + Tech(par_b_winter) × In('amount_winter');

19.5 Detailed process description

This formula takes into account the amount of concentrates used per cow during the winter and summer feeding period. The correction is based on the fact that concentrates (grains) can specifically balance the energy to protein ratio, thus reducing the crude protein.

19.5.1 References:

Flückiger E 1989. Stickstoff- und Mineralstoffumsatz von Milchkühen in Abhängigkeit von Rationentyp und Produktionsphase unter besonderer Berücksichtigung umweltrelevanter Aspekte. Diss ETH Nr 8865.

20 Livestock::DairyCow::Excretion::CFeed

Agrammon Group – 13-11-09

20.1 Short description

Computes the correction factor for the annual N excretion of a dairy cow as a function of the summer and winter feed ration, and the amount and type of concentrates used.

20.2 Input parameters

20.3 Technical parameters

20.4 Output

Parameter	Unit	Formula
c_feed_ration	-	Feed ration correction factor for annual N excretion. 1 + (Tech(d_summer) × Val(c_summer_ration, CFeedSummerRatio) + Tech(d_winter) × Val(c_winter_ration, CFeedWinterRatio) + Tech(d_summer) × Val(c_concentrates_summer, CConcentrates) + Tech(d_winter) × Val(c_concentrates_winter, CConcentrates));

20.5 Detailed process description

This process accounts for the fact, that special rations can result in higher or lower N excretions as compared to standard excretions from Flisch et al. (2009). A differentiated consideration of the duration of the summer and winter feeding period according to farm location (altitude etc.) is possible but was not implemented for the emission inventory.

20.5.1 References:

Flisch R, Sinaj S, Charles R, Richner W 2009. Grundlagen für die die Düngung im Acker- und Futterbau. Agrarforschung 16(2).

21 Livestock::DairyCow::Excretion::CFeedSummerRatio

Agrammon Group – 13-11-09

21.1 Short description

Computes the correction factor for the annual N excretion of a dairy cow as a function of the summer feed ration.

21.2 Input parameters

21.3 Technical parameters

21.4 Output

Parameter	Unit	Formula
c_summer_ration	-	Summer feed ration correction factor for annual N excretion. Tech(c_hay_summer) × Out('share_hay_summer') + Tech(c_maize_silage_summer) × Out('share_maize_silage_summer') + Tech(c_maize_pellets_summer) × Out('share_maize_pellets_summer');

share_hay_summer	-	Share
		
		if (In('share_hay_summer') > 1) {
		return (In('share_hay_summer')/100);
		} else {
		return (In('share_hay_summer'));
		};

share_maize_silage_summer	-	Share
		
		if (In('share_maize_silage_summer') > 1) {
		return (In('share_maize_silage_summer')/100);
		} else {
		return (In('share_maize_silage_summer'));
		};

share_maize_pellets-_summer	-	Share
		
		if (In('share_maize_pellets_summer') > 1) {
		return (In('share_maize_pellets_summer')/100);
		} else {
		return (In('share_maize_pellets_summer'));
		};

21.5 Detailed process description

This process calculates the correction factor for N excretion during the summer feeding period as compared to the standard excretion values of Walther et al. (2001). The average feed ration considered for the standard excretion presented in Walther et al. (2001) was calculated as average of four summer and four winter standard rations using dsummer and dwinter mentioned above. To calculate the N excretion of farm-specific summer rations, excretions were calculated with the same model used by the authors of Walther et al. (2001) (based on official feeing recommendations (RAP 1999)) using proportions of the specific feed typically used on farms (expert assumptions). No correction was considered for grass and grass silage, because grass is used by virtually all farms during the summer feeding period und because the crude protein content of grass silage is not much lower than that of grass. The thus calculated summer excretions were then expressed as

21.5.1 References:

RAP 1999. Fütterungsempfehlungen und Nährwerttabellen für Wiederkäuer. 4. überarbeitete Auflage. LMZ Zollikofen. Walther U, Ryser JP, Flisch R (Eds.) 2001. Grundlagen für die Düngung im Acker- und Futterbau 2001. Agrarforschung 8:1-80.

22 Livestock::DairyCow::Excretion::CFeedWinterRatio

Agrammon Group – 13-11-09

22.1 Short description

Computes the correction factor for the annual N excretion of a dairy cow as a function of the winter feed ration.

22.2 Input parameters

22.3 Technical parameters

22.4 Output

Parameter	Unit	Formula

share_maize_pellets_winter	-	Share
		
		if (In('share_maize_pellets_winter') > 1) {
		return (In('share_maize_pellets_winter')/100);
		} else {
		return (In('share_maize_pellets_winter'));
		};

share_potatoes_winter	-	Share
		
		if (In('share_potatoes_winter') > 1) {
		return (In('share_potatoes_winter')/100);
		} else {
		return (In('share_potatoes_winter'));
		};

share_beets_winter	-	Share
		
		if (In('share_beets_winter') > 1) {
		return (In('share_beets_winter')/100);
		} else {
		return (In('share_beets_winter'));
		};

c_winter_ration	-	Winter feed ration correction factor for annual N excretion. Tech(c_grass_silage_winter) × Out('share_grass_silage_winter') + Tech(c_maize_silage_winter) × Out('share_maize_silage_winter') + Tech(c_maize_pellets_winter) × Out('share_maize_pellets_winter') + Tech(c_potatoes_winter) × Out('share_potatoes_winter') + Tech(c_beets_winter) × Out('share_beets_winter');

share_maize_silage_winter	-	Share
		
		if (In('share_maize_silage_winter') > 1) {
		return (In('share_maize_silage_winter')/100);
		} else {
		return (In('share_maize_silage_winter'));
		};

share_grass_silage_winter	-	Share
		
		if (In('share_grass_silage_winter') > 1) {
		return (In('share_grass_silage_winter')/100);
		} else {
		return (In('share_grass_silage_winter'));
		};

22.5 Detailed process description

This process calculates the correction factor for the N excretion during the winter feeding period as compared to the standard excretion values of Walther et al. (2001). The average feed ration considered for the standard excretion presented in Walther et al. (2001) was calculated as average of four summer and four winter standard rations using dsummer and dwinter mentioned above. To calculate the N excretion of farm-specific winter rations, excretions were calculated with the same model used by the authors of Walther et al. (2001) (based on official feeding recommendations (RAP 1999)) using proportions of the specific feed typically used on farms (expert assumptions). No correction was considered for hay, because hay is used by virtually all farms during the winter feeding period. The thus calculated winter excretions were then expressed as

22.5.1 References:

RAP 1999. Fütterungsempfehlungen und Nährwerttabellen für Wiederkäuer. 4. überarbeitete Auflage. LMZ Zollikofen. Walther U,Ryser JP, Flisch R (Eds.) 2001. Grundlagen für die Düngung im Acker- und Futterbau 2001. Agrarforschung 8:1-80.

23 Livestock::DairyCow::Excretion::CMilk

Agrammon Group – 13-11-09

23.1 Short description

Computes the correction factor for the annual N excretion of a dairy cow as a function of the milk yield.

23.2 Input parameters

23.3 Technical parameters

23.4 Output

Parameter	Unit	Formula

cmilk_yield	-	Milk yield correction factor for annual N excretion.
		
		my $a;
		if (In('milk_yield') > Tech(standard_milk_yield)) {
		$a = Tech(a_high);
		}
		else {
		$a = Tech(a_low);
		}
		
		return (1 + ((In('milk_yield')
		- Tech(standard_milk_yield))/1000) × $a);

23.5 Detailed process description

This process describes the relationship between the milk yield and the N excretion. While the N excretion decreases by 10

23.5.1 References:

Flisch R, Sinaj S, Charles R, Richner W (Eds.) 2009. Grundlagen für die die Düngung im Acker- und Futterbau 2009 (GRUDAF), Agrarforschung 16.2.

24 Livestock::DairyCow::Grazing

Agrammon Group – 13-11-09

24.1 Short description

Computes the annual NH3 emission from grazing dairy cows.

24.2 Input parameters

24.3 Technical parameters

24.4 Output

Parameter	Unit	Formula
grazing_days	d /a	Grazing days per year. In(grazing_days);
nh3_ngrazing	kg N /a	Annual total NH3 emission from all grazing dairy cows. Out(n_sol_into_grazing) × Tech(er_dairycow_grazing);
n_into_grazing	kg N /a	Annual total N excretion during grazing for dairy cows. Val(n_excretion, Excretion) × In(grazing_days) / 365 × In(grazing_hours) / 24;
n_remain_pasture	kg N /a	Annual N input on pasture. Out(n_into_grazing) - Out(nh3_ngrazing);

nh3_ngrazing_animal	kg N /a	Annual NH3 emission per dairy cow from grazing.
		
		if(Val(dairy_cows, Excretion) != 0){
		return Out(nh3_ngrazing) / Val(dairy_cows, Excretion);
		} else { return 0;};

n_sol_into_grazing	kg N /a	Annual soluble N (TAN) excretion during grazing for dairy cows. Val(n_sol_excretion, Excretion) × In(grazing_days) / 365 × In(grazing_hours) / 24;
grazing_hours	h /d	Grazing hours per day. In(grazing_hours);

24.5 Detailed process description

This process calculates the annual NH3 emission from grazing dairy cows based on the total N excreted on the pastures. The N excreted is calculated according to the time the animals spend on the pasture. It assumes that the excretions on the pasture are proportional to the time the animals are grazed.

24.5.1 References:

Bussink DW 1992. Ammonia volatilization from grassland receiving nitrogen fertilizer and rotationally grazed by dairy cattle. Fertilizer Research 33:257-265.

Bussink DW 1994. Relationship between ammonia volatilization and nitrogen fertilizer application rate, intake and excretion of herbage nitrogen by cattle on grazed swards. Fertilizer Research 38:111-121.

Jarvis SC, Hatch DJ, Lockyer DR 1989. Ammonia fluxes from grazed grassland: annual losses from cattle production systems and their relation to nitrogen inputs. Journal of Agricultural Science 113:99-108.

Peterson SO, Sommer SG, Aaes O, Soegaard K 1998. Ammonia losses from urine and dung of grazing cattle: effect of N intake. Atmospheric environment 32:295-300.

Ross CA, Jarvis SC 2001. Measurement of emission and deposition pattern of ammonia from urine in grass swards. Atmospheric environment 35:867-875.

25 Livestock::DairyCow::Housing

Agrammon Group – 13-11-09

25.1 Short description

Computes the annual NH3 emission from dairy cow housing systems.

25.2 Input parameters

25.3 Technical parameters

25.4 Output

Parameter	Unit	Formula
tan_outhousing_liquid	kg N /a	Annual N flux as TAN out of housing, slurry or liquid fraction of manure from dairy cows. Out(n_outhousing) × Val(share_liquid, Housing::Type) × Out(share_tan_out);
n_outhousing_liquid	kg N /a	Annual N flux out of housing, slurry or liquid fraction of manure from dairy cows. Out(n_outhousing) × Val(share_liquid, Housing::Type);
n_outhousing	kg N /a	Annual N flux out of the housing. Out(n_into_housing) - Out(nh3_nhousing);
n_into_housing	kg N /a	Annual N flux into the house. Val(n_excretion, Excretion) - Val(n_into_grazing, Grazing) - Val(n_into_yard, Yard);
tan_outhousing	kg N /a	Annual N flux as TAN out of the housing. Out(n_sol_into_housing) - Out(nh3_nhousing);
nh3_nhousing	kg N /a	Annual NH3 emission from dairy cow housing systems per animal place. (Val(n_sol_excretion, Excretion) - Val(n_sol_reduction_house, Yard)) × Val(k_grazing, Housing::KGrazing) × Val(er_housing, Housing::Type) × Val(k_area, Housing::Type) × Val('c_UNECE', Housing::Floor);
n_sol_into_housing	kg N /a	Annual N flux as TAN into the house. Val(n_sol_excretion, Excretion) - Val(n_sol_into_grazing, Grazing) - Val(n_sol_into_yard, Yard);
tan_outhousing_solid	kg N /a	Annual N flux as TAN out of housing from solid fraction of manure. Out(n_outhousing) × (1 - Val(share_liquid, Housing::Type)) × Out(share_tan_out);
n_outhousing_solid	kg N /a	Annual N flux out of housing from solid fraction of manure. Out(n_outhousing) × (1 - Val(share_liquid, Housing::Type));
share_tan_out	-	Share of TAN for interface to storage, the same share is assumed for solid and liquid parts of output. Mineralization and immobilization are considerd in the storage module. if(Out(n_outhousing) != 0){ Out(tan_outhousing) / Out(n_outhousing) }else{0};

25.5 Detailed process description

This process calculates the NH3 emission in dairy cow housing depending on the N excretion and the housing systems. The NH3 emission is assumed to be proportional to the total N excretion of the animals because the contaminated surfaces will primarily drive emission, which will remain active even when animals are on the pasture or exercise yard.

A proportional correction is applied according to the area per animal.

A correction is applied if the part of the day grazing is above a defined grazing hours per days.

25.5.1 Definition of System boundaries for the housing Process:

For housing systems with integrated exercise yards, it is difficult to distinguish between emissions from housing, exercise yard and storage. For these housingtypes the emission may be only validated for the sum of housing, exercise yard and storage emission.

26 Livestock::DairyCow::Housing::Floor

Agrammon Group – 13-11-09

26.1 Short description

Computes the annual NH3 reduction due to a grooved floor in housing systems.

26.2 Input parameters

26.3 Technical parameters

26.4 Output

Parameter	Unit	Formula

c_UNECE	-	Reduction factor for the emission due to the use of a grooved floor in housing systems.
		
		if (In('UNECE_category_1_mitigation_options_for_housing_systems_for_dairy_cows') eq 'toothed_scrapper_running_over_a_grooved_floor'){
		return (1 - Tech('red_UNECE'));
		} else { return 1;};

26.5 Detailed process description

This submodul calculates the annual NH3 reduction due to a grooved floor in housing systems according to the UNECE guideline 2007.

26.5.1 References

UNECE 2007. Guidance document on control techniques for preventing and abating emissions of ammonia. ECE/EB.AIR/WG.5/2007/13.

27 Livestock::DairyCow::Housing::KGrazing

Agrammon Group – 13-11-09

27.1 Short description

Computes the correction factor for the reduction of the housing emission if the number of grazing hours per day does increase a specific limit.

27.2 Input parameters

27.3 Technical parameters

27.4 Output

Parameter	Unit	Formula

k_grazing	-	The correction factor for the reduction of the housing emission depending on the number of grazing hours per day and the grazing days per year.
		
		if (Val('grazing_hours', '..::Grazing') < 5){
		return ((365.0-Val('grazing_days', '..::Grazing')) + ((1-Tech(k_grazing_reduction_lw5h))×Val('grazing_days', '..::Grazing'))) / 365.0 ;
		}
		elsif (Val('grazing_hours', '..::Grazing') < 12.0){
		return ((365.0-Val('grazing_days', '..::Grazing')) + ((1-Tech(k_grazing_reduction_lw12h))×Val('grazing_days', '..::Grazing'))) / 365.0 ;
		}
		elsif (Val('grazing_hours', '..::Grazing') < 22.0) {
		return ((365.0-Val('grazing_days', '..::Grazing')) + ((1-Tech(k_grazing_reduction_lw22h))×Val('grazing_days', '..::Grazing'))) / 365.0 ;
		}
		elsif (Val('grazing_hours', '..::Grazing') ≥ 22.0) {
		return ((365.0-Val('grazing_days', '..::Grazing')) + ((1-Tech(k_grazing_reduction_gt22h))×Val('grazing_days', '..::Grazing'))) / 365.0 ;
		}
		else {
		return 1; # no correction
		};

27.5 Detailed process description

This process calculates the correction factor for the non proportional change of the housing emission according to the grazing hours per day (Webb et al. 2005). It is based on an empirical estimation of Menzi and Katz (1997). The concept has been lately supported by measurements in the UK (Defra 2005), where reductions comparable to those assumed by Menzi and Katz (1997) were reported.

27.5.1 References:

Department for Environment, Food & Rural Affairs, Defra 2002. Ammonia in the UK. DEFRA Publications, London. Menzi H, Katz PE 1997. A differentiated approach to calculate ammonia emissions from animal husbandry. In: Voermans JAM and Monteny GJ (Eds): "Ammonia and odour emissions from animal production facilities", Proc. International Symposium, Vinkeloord, NL, 6-10 October 1997, 35-42. Webb J, Misselbrook TH 2005. A mass-flow model of ammonia emissions from UK livestock production. Atmospheric environment 38: 2163-2176.

28 Livestock::DairyCow::Housing::Type

Agrammon Group – 13-11-09

28.1 Short description

Selects the emission rate and other correction factors for the specific housing types for dairy cows.

28.2 Input parameters

28.3 Technical parameters

28.4 Output

Parameter	Unit	Formula
housing_type	-	Housing type (needed in other modules). In('housing_type');

area_increase	-	Factor on what barn size does increase the regularized minimal, limited to 0.5.
		
		if((Val(dairy_cows, '..::Excretion') < In('dimensioning_barn')) and (Val(dairy_cows, '..::Excretion') != 0)){
		if(In('dimensioning_barn') $\geq$ (Val(dairy_cows, '..::Excretion') $\times$ 1.5)){
		return 0.5;
		}
		else {
		if(Val('dairy_cows', '..::Excretion') > 0){
		return((In('dimensioning_barn') / Val(dairy_cows, '..::Excretion')) -1);
		}else { return 0;}
		}
		
		}
		else {
		return 0.0;
		};

share_liquid	-	Liquid share for the housing type. Val(share_liquid, 'Type::' . In('housing_type'));
er_housing	-	Emission rate for the housing type. Val('er_housing', 'Type::' . In('housing_type'));
k_area_type	-	Correction factor for the housing type area. Val(k_area, 'Type::' . In('housing_type'));
share_solid	-	Solid share for the housing type. Val(share_solid, 'Type::' . In('housing_type'));
k_area	-	Correction factor for area per animal. 1 + (Out(area_increase) $\times$ Out(k_area_type));

28.5 Detailed process description

This process selects the correction factor for the specific housing types for dairy cows. Among these correction factors are the emission rate for the housing type, the correction factor for the housing type area, the correction factor for the area per animal, the liquid and solid share for the housing type as well as the factor on what barn size increases the regularized minimal (limited to 0.5).

29 Livestock::DairyCow::Housing::Type::Loose_Housing_Deep_Litter

Agrammon Group – 13-11-09

29.1 Short description

Describes correction factors for the loose housing deep litter system for dairy cows.

29.2 Input parameters

29.3 Technical parameters

29.4 Output

Parameter	Unit	Formula
share_liquid	-	Part of Ntot flowing into liquid storage for selected housing type. Tech(share_liquid);
er_housing	-	Emission rate for specific housing type. Tech(er);
share_solid	-	Share of solid manure of Ntot for selected housing type. 1-Tech(share_liquid);
k_area	-	Correction factor for area per animal. Tech(k_area);

29.5 Detailed process description

This process describes the correction factors for the loose housing deep litter system for dairy cows such as the housing specific emission rate, the area per animal correction, the liquid share and solid share.

29.5.1 References:

UNECE 2007. Guidance document on control techniques for preventing and abating emissions of ammonia. UNECE executive body for the convention on long-range transboundary air pollution, Working Group on Strategies and Review, EB.AIR/WH.5/2007/13/ 16 July 2007, Genf. 35p.

30 Livestock::DairyCow::Housing::Type::Loose_Housing_Slurry

Agrammon Group – 13-11-09

30.1 Short description

Describes correction factors for the loose housing slurry system for dairy cows.

30.2 Input parameters

30.3 Technical parameters

30.4 Output

Parameter	Unit	Formula
share_liquid	-	Part of Ntot flowing into liquid storage for selected housing type. Tech(share_liquid);
er_housing	-	Emission rate for specific housing type. Tech(er);
share_solid	-	Share of solid manure of Ntot for selected housing type. 1-Tech(share_liquid);
k_area	-	Correction factor for area per animal. Tech(k_area);

30.5 Detailed process description

This process describes the correction factors for the loose housing slurry system for dairy cows such as the housing specific emission rate, the area per animal correction, the liquid share and solid share.

30.5.1 References:

UNECE 2007. Guidance document on control techniques for preventing and abating emissions of ammonia. UNECE executive body for the convention on long-range transboundary air pollution, Working Group on Strategies and Review, EB.AIR/WH.5/2007/13/ 16 July 2007, Genf. 35p.

31 Livestock::DairyCow::Housing::Type::Loose_Housing_Slurry-_Plus_Solid_Manure

Agrammon Group – 13-11-09

31.1 Short description

Describes correction factors for the loose housing liquid solid system for dairy cows.

31.2 Input parameters

31.3 Technical parameters

31.4 Output

Parameter	Unit	Formula
share_liquid	-	Part of Ntot flowing into liquid storage for selected housing type. Tech(share_liquid);
er_housing	-	Emission rate for specific housing type. Tech(er);
share_solid	-	Share of solid manure of Ntot for selected housing type. 1-Tech(share_liquid);
k_area	-	Correction factor for area per animal. Tech(k_area);

31.5 Detailed process description

This process describes the correction factors for the loose housing liquid solid system for dairy cows such as the housing specific emission rate, the area per animal correction, the liquid share and solid share.

31.5.1 References:

UNECE 2007. Guidance document on control techniques for preventing and abating emissions of ammonia. UNECE executive body for the convention on long-range transboundary air pollution, Working Group on Strategies and Review, EB.AIR/WH.5/2007/13/ 16 July 2007, Genf. 35p.

32 Livestock::DairyCow::Housing::Type::Tied_Housing_Slurry

Agrammon Group – 13-11-09

32.1 Short description

Describes correction factors for the tied housing slurry system for daiy cows.

32.2 Input parameters

32.3 Technical parameters

32.4 Output

Parameter	Unit	Formula
share_liquid	-	Part of Ntot flowing into liquid storage for selected housing type. Tech(share_liquid);
er_housing	-	Emission rate for specific housing type. Tech(er);
share_solid	-	Share of solid manure of Ntot for selected housing type. 1-Tech(share_liquid);
k_area	-	Correction factor for area per animal. Tech(k_area);

32.5 Detailed process description

This process describes the correction factors for the tied housing slurry system for dairy cows such as the housing specific emission rate, the area per animal correction, the liquid share and solid share.

33 Livestock::DairyCow::Housing::Type::Tied_Housing_Slurry_Plus_Solid_Manure

Agrammon Group – 13-11-09

33.1 Short description

Describes correction factors for the tied housing liquid solid system for dairy cows.

33.2 Input parameters

33.3 Technical parameters

33.4 Output

Parameter	Unit	Formula
share_liquid	-	Part of Ntot flowing into liquid storage for selected housing type. Tech(share_liquid);
er_housing	-	Emission rate for specific housing type. Tech(er);
share_solid	-	Share of solid manure of Ntot for selected housing type. 1-Tech(share_liquid);
k_area	-	Correction factor for area per animal. Tech(k_area);

33.5 Detailed process description

This process describes the correction factors for the tied housing liquid solid system for dairy cows such as the housing specific emission rate, the area per animal correction, the liquid share and solid share.

34 Livestock::DairyCow::Yard

Agrammon Group – 13-11-09

34.1 Short description

Computes the annual NH3 emission from dairy cow on exercise yards based on the access time and if the the basic feeding is on the yard.

34.2 Input parameters

34.3 Technical parameters

34.4 Output

Parameter	Unit	Formula
n_into_yard	kg N /a	Annual N excretion on yard for a defined animal category. Val(n_excretion, Excretion) × (In('yard_days') / 365) × Out(share_excretion_yard);
tan_outyard_solid	kg N /a	Annual N flux as TAN from solid part out of yard into storage. 0;

nh3_nyard_animal	kg N /a	Annual NH3 emission per anmimal from yard.
		
		if(Val(dairy_cows, Excretion) != 0){
		return Out(nh3_nyard) / Val(dairy_cows, Excretion);
		} else { return 0;};

share_excretion_yard	-	Share of excretion on the yard according the stay on yard. If the basic feeding is on the yard the share_basicfeeding is assumed. Otherwise the share is selected according to the access.
		
		if(In('exercise_yard') eq 'available_roughage_is_not_supplied_in_the_exercise_yard')
		{
		return Tech('share_available_roughage_is_not_supplied_in_the_exercise_yard');
		} elsif(In('exercise_yard') eq 'available_roughage_is_partly_supplied_in_the_exercise_yard') {
		return Tech('share_available_roughage_is_partly_supplied_in_the_exercise_yard');
		} elsif(In('exercise_yard') eq 'available_roughage_is_exclusively_supplied_in_the_exercise_yard') {
		return Tech('share_available_roughage_is_exclusively_supplied_in_the_exercise_yard');
		} elsif(In('exercise_yard') eq 'not_available') {
		return 0;
		};

nh3_nyard	kg N /a	Annual NH3 emission from yard. Out(n_sol_into_yard) × Tech(er_yard) × (1 - (Out(c_floor_properties_exercise_yard)));

n_sol_reduction_house	-	Reduction of excerteion in housing according to extensive use of the Yard, when the basic feeding is on the yard.
		
		if(In('exercise_yard') eq 'available_roughage_is_exclusively_supplied_in_the_exercise_yard')
		{
		return (Val(n_sol_excretion, Excretion)
		× (In('yard_days') / 365)
		× Out(share_excretion_yard) × 0.5
		);
		} else {
		return 0.0;
		}

n_outyard	kg N /a	Annual N flux out of yard. Out(n_into_yard) - Out(nh3_nyard);

n_sol_into_yard	kg N /a	Annual soluble N excretion on yard for a defined animal category. Val(n_sol_excretion, Excretion) × (In('yard_days') / 365) × Out(share_excretion_yard);
n_outyard_liquid	kg N /a	Annual N flux from liquid part out of yard. Out(n_into_yard) - Out(nh3_nyard);
n_outyard_solid	kg N /a	Annual N flux from solid part out of yard. 0;
tan_outyard_liquid	kg N /a	Annual N flux as TAN from liquid part out of yard into storage. Out(n_sol_into_yard) - Out(nh3_nyard);
tan_outyard	kg N /a	Annual N flux as TAN out of yard into storage. Out(n_sol_into_yard) - Out(nh3_nyard);

c_floor_properties_exercise-_yard	-	Reduction factor for the emission due to the use of the floor properties in housing systems.
		
		if (In('floor_properties_exercise_yard') eq 'solid_floor'){
		return Tech('red_floor_properties_solid_floor');
		} elsif (In('floor_properties_exercise_yard') eq 'unpaved_floor'){
		return Tech('red_floor_properties_unpaved_floor');
		} elsif (In('floor_properties_exercise_yard') eq 'perforated_floor'){
		return Tech('red_floor_properties_perforated_floor');
		} elsif (In('floor_properties_exercise_yard') eq 'pad-dock_or_pasture_used_as_exercise_yard'){
		return Tech('red_floor_properties_paddock_or_pasture_used_as_exercise_yard');
		} else{ return 0;};

34.5 Detailed process description

35 Livestock::Equides

Agrammon Group – 13-11-09

35.1 Short description

Collects the annual emission of NH3 and the N flux for equides.

35.2 Input parameters

35.3 Technical parameters

35.4 Output

Parameter	Unit	Formula
n_solid_from_equides	kg N /a	Annual N flux from equides housing and yard, solid fraction. Val('n_outhousing_solid', Equides::Housing) + Val('n_outyard_solid', Equides::Yard);
n_liquid_from_equides	kg N /a	Annual N flux from equides housing and yard, liquid fraction. Val('n_outhousing_liquid', Equides::Housing) + Val('n_outyard_liquid', Equides::Yard);
tan_from_equides	kg N /a	Annual N flux as TAN from dairy cow housing and yard. Val(tan_outhousing, Equides::Housing) + Val(tan_outyard, Equides::Yard);
tan_solid_from_equides	kg N /a	Annual N flux as TAN from equides housing and yard, solid fraction. Val('tan_outhousing_solid', Equides::Housing) + Val('tan_outyard_solid', Equides::Yard);
tan_liquid_from_equides	kg N /a	Annual N flux as TAN from dairy cow housing and yard, liquid fraction. Val('tan_outhousing_liquid', Equides::Housing) + Val('tan_outyard_liquid', Equides::Yard);
n_excretion	kg N /a	Annual N excreted by equides. Val('n_excretion', Equides::Excretion);
n_from_equides	kg N /a	Annual N flux from equides housing and yard. Val('n_outhousing', Equides::Housing) + Val('n_outyard', Equides::Yard);
nh3_nequides	kg N /a	Annual NH3 emission from equides housing, yard and grazing (production). Val('nh3_nhousing', Equides::Housing) + Val('nh3_nyard', Equides::Yard) + Val('nh3_ngrazing', Equides::Grazing);

35.5 Detailed process description

This process summarizes the annual emission of NH3 for equides from housing, yard and grazing. Further it summarizes the annual N flux from the housing to the storage for equides.

36 Livestock::Equides::Excretion

Agrammon Group – 13-11-09

36.1 Short description

Computes the annual N excretion of horses, mules and asses.

36.2 Input parameters

36.3 Technical parameters

36.4 Output

Parameter	Unit	Formula
n_sol_excretion	kg N /a	Annual soluble N excreted by a specified number of animals. Out(share_Nsol) × Out(n_excretion);

standard_N_excretion	kg N /a	Annual standard N excretion for specified other animal category according to Flisch et al. (2009).
		
		my $key = "standard_N_excretion_" . In('animalcategory');
		return Tech($key);

animals	-	Number of other animals for the selected type in barn. In(animals);
n_excretion	kg N /a	Annual N excreted by a specified number of animals. Out(standard_N_excretion) × In(animals);

share_Nsol	-	Nsol content of excreta of other animal category. Derived from e.g. Peterson et al. (1998) or Burgos et al. (2005).
		
		my $key = "share_Nsol_" . In('animalcategory');
		return Tech($key);

36.5 Detailed process description

This process calculated the annual N excretion of the animal categories listed above. The standard N excretion was taken from the official Swiss fertilizer guidelines. The Nsol content of the excreta is based on e.g. Peterson et al. (1998) or Burgos et al. (2005). These values were compiled on the basis of official feeding recommendations (Flisch et al. 2009) by H. Menzi.

36.5.1 References:

Burgos SA, Robinson PH, Fadel JG, DePeters EJ 2005. Ammonia volatilization potential: Prediction of urinary urea nitrogen output on lactating dairy cows. Agriculture, Ecosystems and Environment 111:261-269.

Peterson SO, Sommer SG, Aaes O, Soegaard K 1998. Ammonia losses from urine and dung of grazing cattle: effect of N intake. Atmospheric environment 32:295-300.

Flisch R, Sinaj S, Charles R, Richner W 2009. Grundlagen für die die Düngung im Acker- und Futterbau. Agrarforschung 16(2).

37 Livestock::Equides::Grazing

Agrammon Group – 13-11-09

37.1 Short description

Computes the annual NH3 emission from grazing of equides, such as horses, mules, asses.

37.2 Input parameters

37.3 Technical parameters

37.4 Output

Parameter	Unit	Formula
grazing_days	d /a	Grazing days per year. In(grazing_days);
nh3_ngrazing	kg N /a	Annual NH3 emission from equides from grazing. Out(n_sol_into_grazing) × Tech(er_equides_grazing);
n_into_grazing	kg N /a	Annual N excretion during grazing for equides. Val(n_excretion, Excretion) × In(grazing_days) / 365 × In(grazing_hours) / 24;
n_remain_pasture	kg N /a	Annual N input on pastures. Out(n_into_grazing) - Out(nh3_ngrazing);
n_sol_into_grazing	kg N /a	Annual solable N (TAN) excretion during grazing for equides. Val(n_sol_excretion, Excretion) × In(grazing_days) / 365 × In(grazing_hours) / 24;
grazing_hours	h /d	Grazing hours per day. In(grazing_hours);

37.5 Detailed process description

This process calculates the annual NH3 emission from grazing of equides (horses, mules, asses) based on the total N excreted on the pastures. The N excreted is calculated according to the time the animals spend on the pasture. It assumes that the excretions on the pasture are proportional to the time the animals are grazed.

37.5.1 References:

Bussink DW 1992. Ammonia volatilization from grassland receiving nitrogen fertilizer and rotationally grazed by dairy cattle. Fertilizer Research 33:257-265.

Bussink DW 1994. Relationship between ammonia volatilization and nitrogen fertilizer application rate, intake and excretion of herbage nitrogen by cattle on grazed swards. Fertilizer Research 38:111-121.

Jarvis SC, Hatch DJ, Lockyer DR 1989. Ammonia fluxes from grazed grassland: annual losses from cattle production systems and their relation to nitrogen inputs. Journal of Agricultural Science 113:99-108.

Peterson SO, Sommer SG, Aaes O, Soegaard K 1998. Ammonia losses from urine and dung of grazing cattle: effect of N intake. Atmospheric environment 32:295-300.

Ross CA, Jarvis SC 2001. Measurement of emission and deposition pattern of ammonia from urine in grass swards. Atmospheric environment 35:867-875.

38 Livestock::Equides::Housing

Agrammon Group – 13-11-09

38.1 Short description

Computes the annual NH3 emission from equides housing systems.

38.2 Input parameters

38.3 Technical parameters

38.4 Output

Parameter	Unit	Formula
tan_outhousing_liquid	kg N /a	Annual N flux as TAN out of housing, slurry or liquid fraction of N flux. 0
n_outhousing_liquid	kg N /a	Annual N flux out of housing, slurry or liquid fraction of N flux. 0
n_outhousing	kg N /a	Annual N flux out of the housing. Out(n_into_housing) - Out(nh3_nhousing);
n_into_housing	kg N /a	Annual N flux into the house. Val(n_excretion, Excretion) - Val(n_into_grazing, Grazing) - Val(n_into_yard, Yard);
tan_outhousing	kg N /a	Annual N flux as TAN out of the housing. Out(n_sol_into_housing) - Out(nh3_nhousing);
nh3_nhousing	kg N /a	Annual NH3 emission from equides housing systems. per animal place. Val(n_excretion, Excretion) × Tech(er_housing) × Val(k_grazing, Housing::KGrazing)
n_sol_into_housing	kg N /a	Annual N flux as TAN into the house. Val(n_sol_excretion, Excretion) - Val(n_sol_into_grazing, Grazing) - Val(n_sol_into_yard,Yard);
tan_outhousing_solid	kg N /a	Annual N flux as TAN out of housing, manure fraction of N flux. Out(tan_outhousing);
n_outhousing_solid	kg N /a	Annual N flux out of housing, manure fraction of N flux. Out(n_outhousing);

38.5 Detailed process description

This process calculates the NH3 emission in equides housing depending on the N excretion and the housing systems. The NH3 emission is assumed to be proportional to the total N excretion of the animals because the contaminated surfaces will primarily drive emissions, which will remain active even when animals are on the pasture or exercise yard.

A proportional correction is applied according to the area per animal.

A correction is applied if the part of the day grazing is above a defined grazing hours per days.

38.5.1 Definition of System boundaries for the housing Process:

For housing systems with integrated exercise yards, it is difficult to distinguish between emissions from housing, exercise yard and storage. For these housingtypes the emission may be only validated for the sum of housing, exercise yard and storage emission.

39 Livestock::Equides::Housing::KGrazing

Agrammon Group – 13-11-09

39.1 Short description

Computes the correction factor for the reduction of the housing emission if the number of grazing hours per day does increase a specific limit.

39.2 Input parameters

39.3 Technical parameters

39.4 Output

Parameter	Unit	Formula

k_grazing	-	The correction factor for the reduction of the housing emission depending on the number of grazing hours per day and the grazing days per year.
		
		if (Val('grazing_hours', '..::Grazing') < 5){
		return ((365.0-Val('grazing_days', '..::Grazing')) + ((1-Tech(k_grazing_reduction_lw5h))×Val('grazing_days', '..::Grazing'))) / 365.0 ;
		}
		elsif (Val('grazing_hours', '..::Grazing') < 12.0){
		return ((365.0-Val('grazing_days', '..::Grazing')) + ((1-Tech(k_grazing_reduction_lw12h))×Val('grazing_days', '..::Grazing'))) / 365.0 ;
		}
		elsif (Val('grazing_hours', '..::Grazing') < 22.0) {
		return ((365.0-Val('grazing_days', '..::Grazing')) + ((1-Tech(k_grazing_reduction_lw22h))×Val('grazing_days', '..::Grazing'))) / 365.0 ;
		}
		elsif (Val('grazing_hours', '..::Grazing') ≥ 22.0) {
		return ((365.0-Val('grazing_days', '..::Grazing')) + ((1-Tech(k_grazing_reduction_gt22h))×Val('grazing_days', '..::Grazing'))) / 365.0 ;
		}
		else {
		return 1; # no correction
		};

39.5 Detailed process description

This process calculates the correction factor for the non proportional change of the housing emission according to the grazing hours per day (Webb et al. 2005). It is based on an empirical estimation of Menzi and Katz (1997). The concept has been lately supported by measurements in the UK (Defra 2005), where reductions comparable to those assumed by Menzi and Katz (1997) were reported.

39.5.1 References:

Department for Environment, Food & Rural Affairs, Defra 2002. Ammonia in the UK. DEFRA Publications, London. Menzi H, Katz PE 1997. A differentiated approach to calculate ammonia emissions from animal husbandry. In: Voermans JAM and Monteny GJ (Eds): "Ammonia and odour emissions from animal production facilities", Proc. International Symposium, Vinkeloord, NL, 6-10 October 1997, 35-42. Webb J, Misselbrook TH 2005. A mass-flow model of ammonia emissions from UK livestock production. Atmospheric environment 38: 2163-2176.

40 Livestock::Equides::Yard

Agrammon Group – 13-11-09

40.1 Short description

Computes the annual NH3 emission from equides on exercise yards based on the access time and if the the basic feeding is on the yard.

40.2 Input parameters

40.3 Technical parameters

40.4 Output

Parameter	Unit	Formula
n_into_yard	kg N /a	Annual N excretion on yard for a defined animal category. Val(n_excretion, Excretion) × ((In('yard_days') / 365) × (In('yard_hours') /24));
tan_outyard_solid	kg N /a	Annual N flux as TAN from solid part out of yard into storage. Out(n_sol_into_yard) - Out(nh3_nyard);

nh3_nyard_animal	kg N /a	Annual NH3 emission per anmimal from yard.
		
		if(Val(animals, Excretion) != 0){
		return Out(nh3_nyard) / Val(animals, Excretion);
		} else { return 0;};

n_sol_into_yard	kg N /a	Annual soluble N excretion on yard for a defined animal category. Val(n_sol_excretion, Excretion) × ((In('yard_days') / 365) × (In('yard_hours') /24));
nh3_nyard	kg N /a	Annual NH3 emission from yard. Out(n_sol_into_yard) × Tech(er_yard) × (1 - (Out(c_floor_properties_exercise_yard)));
n_outyard_liquid	kg N /a	Annual N flux from liquid part out of yard. 0;
n_outyard_solid	kg N /a	Annual N flux from solid part out of yard. Out(n_into_yard) - Out(nh3_nyard);
tan_outyard_liquid	kg N /a	Annual N flux as TAN from liquid part out of yard into storage. 0;
tan_outyard	kg N /a	Annual N flux as TAN out of yard into storage. Out(n_sol_into_yard) - Out(nh3_nyard);
n_outyard	kg N /a	Annual N flux out of yard. Out(n_into_yard) - Out(nh3_nyard);

c_floor_properties_exercise-_yard	-	Reduction factor for the emission due to the use of the floor properties in housing systems.
		
		if (In('floor_properties_exercise_yard') eq 'unpaved_floor'){
		return Tech('red_floor_properties_unpaved_floor');
		} elsif (In('floor_properties_exercise_yard') eq 'solid_floor'){
		return Tech('red_floor_properties_solid_floor');
		} elsif (In('floor_properties_exercise_yard') eq 'pad-dock_or_pasture_used_as_exercise_yard'){
		return Tech('red_floor_properties_paddock_or_pasture_used_as_exercise_yard');
		} else{ return 0;};

40.5 Detailed process description

40.5.1 References:

Keck M 1997: Ammonia emission and odour thresholds of cattle houses with exercise yards. In: Voermans JAM and Monteny GJ (Eds): "Ammonia and odour emissions from animal production facilities", Proc. International Symposium, Vinkeloord, NL, 6-10 October 1997, 349-354. Misselbrook TH, Webb J, Chadwick DR, Ellis S, Pain BF 2001. Gaseous emissions from outdoor concrete yards used by livestock. Atmospheric Environment 35:5331-5338.

41 Livestock::FatteningPigs

Agrammon Group – 13-11-09

41.1 Short description

Collects the annual emission of NH3 and the N flux for fattening pigs.

41.2 Input parameters

41.3 Technical parameters

41.4 Output

Parameter	Unit	Formula
tan_solid_from_fattening_pig	kg N /a	Annual N flux as TAN from fattening pigs housing, liquid fraction. Val(tan_outhousing_solid, FatteningPigs::Housing);
tan_from_fattening_pig	kg N /a	Annual N flux as TAN from fattening pigs housing. Val(tan_outhousing, FatteningPigs::Housing);
nh3_nfattening_pig	kg N /a	Annual NH3 emission from fattening pigs housing and grazing (production). Val(nh3_nhousing, FatteningPigs::Housing) + Val(nh3_ngrazing, FatteningPigs::Grazing);
n_solid_from_fattening_pig	kg N /a	Annual N flux from fattening pigs housing, solid fraction. Val(n_outhousing_solid, FatteningPigs::Housing);
tan_liquid_from_fattening_pig	kg N /a	Annual N flux as TAN from fattening pigs housing, liquid fraction. Val(tan_outhousing_liquid, FatteningPigs::Housing);
n_from_fattening_pig	kg N /a	Annual N flux from fattening pigs housing. Val(n_outhousing, FatteningPigs::Housing);
n_excretion	kg N /a	Annual N excreted by fattening pigs. Val(n_excretion, FatteningPigs::Excretion);
n_liquid_from_fattening_pig	kg N /a	Annual N flux from fattening pigs housing, liquid fraction. Val(n_outhousing_liquid, FatteningPigs::Housing);

41.5 Detailed process description

This process summarizes the annual emission of NH3 for fattening pigs from housing and grazing. And it summarizes the annual N flux from housing to the storage for fattening pigs.

42 Livestock::FatteningPigs::Excretion

Agrammon Group – 13-11-09

42.1 Short description

Computes the annual N excretion of fattening pigs as a function of the crude protein and the energy content of the feed ration.

42.2 Input parameters

42.3 Technical parameters

42.4 Output

Parameter	Unit	Formula
n_sol_excretion	kg N /a	Annual soluble N excreted by a specified number of fattening pigs. Tech(share_Nsol) × Out(n_excretion);
minimal_N_excretion	kg N /a	Minimal annual N excretion for fattening pigs according to Walther et al. (2001). Tech(minimal_N_excretion_fattening_pigs);

crude_protein	kg N /a	Crude protein content of feed ration - for 1-, 2- or 3-phase-feeding.
		
		if (In(feeding_phase_3_crude_protein) == 0) {
		if ((In(feeding_phase_1_crude_protein) > 100) && (In(feeding_phase_2_crude_protein) > 100)) {
		(In(feeding_phase_1_crude_protein)×Tech(phase_1_2_duration)+
		In(feeding_phase_2_crude_protein)×Tech(phase_2_2_duration))
		} else {
		if (In(feeding_phase_1_crude_protein) > 100){
		In(feeding_phase_1_crude_protein)
		} else {
		ERR "Crude protein must be more than 100!";
		return 0;
		}
		}
		} else {
		if ((In(feeding_phase_1_crude_protein) > 100) && (In(feeding_phase_2_crude_protein) > 100) && (In(feeding_phase_3_crude_protein) > 100)) {
		(In(feeding_phase_1_crude_protein)×Tech(phase_1_3_duration)+
		In(feeding_phase_2_crude_protein)×Tech(phase_2_3_duration)+
		In(feeding_phase_3_crude_protein)×Tech(phase_3_3_duration))
		} else {
		ERR "Crude protein must be more than 100!";
		return 0;
		}
		};

cfeed	-	Correction factor for feed with reduced crude protein content (BLW, SRVA, LBL 2003). Tech(cfeed_fattening_pigs);
standard_crude_protein	g CP /kg	Annual standard N excretion for fattening pigs according to Walther et al. (2001). Tech(standard_crude_protein_fattening_pigs);
fattening_pigs	-	Number of fattening pigs of a specific category. In(fattening_pigs);
standard_N_excretion	kg N /a	Annual standard N excretion for fattening pigs according to Walther et al. (2001). Tech(standard_N_excretion_fattening_pigs);

n_excretion	kg N /a	Annual total N excreted by a specified number of fattening pigs.
		
		if(In('energy_content') != 0){
		Out(standard_N_excretion)
		× (1 - (Out(standard_crude_protein) - Out('crude_protein')) × Out(cfeed))
		× (Out(standard_energy_content) / In('energy_content'))
		× In(fattening_pigs);
		} else {
		ERR "Energy Content can not be 0, use default value!";
		return 0;
		};

standard_energy_content	MJ VES	Standard energy content of the feed ration for fattening pigs. Tech(standard_energy_content_fattening_pigs);

42.5 Detailed process description

This process calculates the annual N excretion (total N and Nsol) of fattening pigs according to the crude protein and energy content of the feed ration.

42.5.1 References:

BLW, SRVA, LBL 2003. Weisungen zur Beruecksichtigung von Ökofuttern in der Suisse-Bilanz. 2003.

Burgos SA, Robinson PH, Fadel JG, DePeters EJ 2005. Ammonia volatilization potential: Prediction of urinary urea nitrogen output on lactating dairy cows. Agriculture, Ecosystems and Environment 111:261-269.

Peterson SO, Sommer SG, Aaes O, Soegaard K 1998. Ammonia losses from urine and dung of grazing cattle: effect of N intake. Atmospheric environment 32:295-300.

Flisch R, Sinaj S, Charles R, Richner W 2009. Grundlagen für die die Düngung im Acker- und Futterbau. Agrarforschung 16(2).

43 Livestock::FatteningPigs::Grazing

Agrammon Group – 13-11-09

43.1 Short description

Computes the annual NH3 emission from grazing fattening pigs.

43.2 Input parameters

43.3 Technical parameters

43.4 Output

Parameter	Unit	Formula
nh3_ngrazing	kg N /a	Annual NH3 emission from all fattening pigs from grazing. Out(n_sol_into_grazing) × Tech(er_fattening_pig_grazing);

share_grazing	-	Share of N excretion during outdoor activities for a defined animal category. If fattening pig housing type is 'Outdoor' 100% is assumed.
		
		if(Val('housing_type', 'Housing::Type') eq 'Outdoor'){
		return 1;
		}else {
		return 0; # no correction
		};

n_into_grazing	kg N /a	Annual N excretion during grazing for fattening pigs. Val('n_excretion', 'Excretion') × Out(share_grazing);
n_remain_pasture	kg N /a	Annual N input on pastures. Out(n_into_grazing) - Out(nh3_ngrazing);
n_sol_into_grazing	kg N /a	Annual soluble N (TAN) excretion during grazing for fattening pigs. Val('n_sol_excretion', 'Excretion') × Out(share_grazing);

43.5 Detailed process description

This process calculates the annual NH3 emission from grazing fattening pigs based on the N excreted on the pastures. The N excreted is calculated according to the time the animals spend on the pasture. It assumes that the excretions on the pasture are proportional to the time the animals are grazed.

43.5.1 References:

Bussink DW 1992. Ammonia volatilization from grassland receiving nitrogen fertilizer and rotationally grazed by dairy cattle. Fertilizer Research 33:257-265.

Bussink DW 1994. Relationship between ammonia volatilization and nitrogen fertilizer application rate, intake and excretion of herbage nitrogen by cattle on grazed swards. Fertilizer Research 38:111-121.

Flisch R, Sinaj S, Charles R, Richner W 2009. Grundlagen für die die Düngung im Acker- und Futterbau. Agrarforschung 16(2).

Jarvis SC, Hatch DJ, Lockyer DR 1989. Ammonia fluxes from grazed grassland: annual losses from cattle production systems and their relation to nitrogen inputs. Journal of Agricultural Science 113:99-108.

Peterson SO, Sommer SG, Aaes O, Soegaard K 1998. Ammonia losses from urine and dung of grazing cattle: effect of N intake. Atmospheric environment 32:295-300.

Ross CA, Jarvis SC 2001. Measurement of emission and deposition pattern of ammonia from urine in grass swards. Atmospheric environment 35:867-875.

44 Livestock::FatteningPigs::Housing

Agrammon Group – 13-11-09

44.1 Short description

Computes the annual NH3 emission from fattening pigs housing systems.

44.2 Input parameters

44.3 Technical parameters

44.4 Output

Parameter	Unit	Formula
n_housing_filter	kg N /a	Annual N of NH3 emission remaining in air scrubber from pig housing systems. Val('n_sol_excretion', 'Excretion') × Val('er_housing', 'Housing::Type') × (1 - Val('c_air_scrubber', 'Housing::AirScrubber')) × (1 - Val('c_UNECE_housing_task', 'Housing::UNECEhousingTask'));

tan_outhousing_liquid	kg N /a	Annual N flux as TAN out of housing, slurry or liquid fraction from fattening pigs.
		
		if(Val(housing_type, Housing::Type) eq 'Outdoor'){
		0
		}else {
		Out(n_outhousing) × Val('share_liquid', 'Housing::Type') × Out(share_tan_out)
		};

n_outhousing_liquid	kg N /a	Annual N flux out of housing, slurry or liquid fraction from fattening pigs.
		
		if(Val(housing_type, Housing::Type) eq 'Outdoor'){
		0
		}else {
		Out(n_outhousing) × Val('share_liquid', 'Housing::Type')
		};

n_outhousing	kg N /a	Annual N flux out of the housing including N remained in biotrickling filter, (without remains in acid filter).
		
		if(Val('housing_type', 'Housing::Type') eq 'Outdoor'){
		0
		}else {
		if(Val('air_scrubber', 'Housing::AirScrubber') eq 'acid'){
		Out(n_into_housing) - Out(nh3_nhousing) - Out(n_housing_filter)
		}else{
		Out(n_into_housing) - Out(nh3_nhousing)
		};
		};

n_into_housing	kg N /a	Annual N flux into the house. Val('n_excretion', 'Excretion') - Val('n_into_grazing', 'Grazing');

tan_outhousing	kg N /a	Annual N flux as TAN out of the housing indcluding N remained in biotrickling filter.
		
		if(Val(housing_type, Housing::Type) eq 'Outdoor'){
		0
		}else {
		if(Val('air_scrubber', 'Housing::AirScrubber') eq 'acid'){
		Out(n_into_housing) - Out(nh3_nhousing) - Out(n_housing_filter)
		}else{
		Out(n_sol_into_housing) - Out(nh3_nhousing)
		};
		};

nh3_nhousing	kg N /a	Annual NH3 emission from fattening pig housing systems. Val('n_sol_excretion', 'Excretion') × Val('er_housing', 'Housing::Type') × Val('c_air_scrubber', 'Housing::AirScrubber') × (1 - Val('c_UNECE_housing_task', 'Housing::UNECEhousingTask'));
n_sol_into_housing	kg N /a	Annual N flux as TAN into the house. Val('n_sol_excretion', 'Excretion') - Val('n_sol_into_grazing', 'Grazing');

tan_outhousing_solid	kg N /a	Annual N flux as TAN out of housing, manure fraction of N flux from fattening pigs.
		
		if(Val(housing_type, Housing::Type) eq 'Outdoor'){
		0
		}else {
		Out(n_outhousing) × (1 - Val('share_liquid', 'Housing::Type')) × Out(share_tan_out)
		};

n_outhousing_solid	kg N /a	Annual N flux out of housing, manure fraction of N flux from fattening pigs.
		
		if(Val('housing_type', 'Housing::Type') eq 'Outdoor'){
		0
		}else {
		Out(n_outhousing) × (1 - Val('share_liquid', 'Housing::Type'))
		};

share_tan_out	-	Share of TAN for interface to storage, the same share is assumed for solid and liquid parts of output. Mineralization and immobilization are considerd in the storage module. if(Out(n_outhousing) != 0){ Out(tan_outhousing) / Out(n_outhousing) }else{0};

44.5 Detailed process description

This process calculates the NH3 emission in fattening pig housing depending on the N excretion and the housing systems. The NH3 emission is assumed to be proportional to the total N excretion of the animals because the contaminated surfaces will primarily drive emissions, which will remain active even when animals are on the pasture or exercise yard.

A proportional correction is applied according to the area per animal.

A correction is applied if the part of the day grazing is above a defined grazing hours per days.

44.5.1 Definition of System boundaries for the housing Process:

For housing systems with integrated exercise yards, it is difficult to distinguish between emissions from housing, exercise yard and storage. For these housingtypes the emission may be only validated for the sum of housing, exercise yard and storage emission.

45 Livestock::FatteningPigs::Housing::AirScrubber

Agrammon Group – 13-11-09

45.1 Short description

Computes the annual NH3 reduction due to an exhaust air scrubber in fattening pig housing systems.

45.2 Input parameters

45.3 Technical parameters

45.4 Output

Parameter	Unit	Formula
air_scrubber	-	air exhaust scrubber in housing systems. In(air_scrubber);

c_air_scrubber	-	Reduction factor for the emission due to the use of an air exhaust scrubber in housing systems.
		
		if (In('air_scrubber') eq 'acid'){
		return (1 - Tech('red_acid_air_scrubber'));
		} elsif(In('air_scrubber') eq 'biotrickling'){
		return (1 - Tech('red_biotrickling_filter_air_scrubber'));
		} elsif(In('air_scrubber') eq 'none'){
		return 1;
		} else{
		ERR "Invalid 'air_scrubber' defined!";
		return 1;
		}

45.5 Detailed process description

This submodul calculates the annual NH3 reduction due to an exhaust air scrubber in fattening pig housing systems according to the UNECE guideline 2007.

45.5.1 References:

UNECE 2007. Guidance document on control techniques for preventing and abating emissions of ammonia. ECE/EB.AIR/WG.5/2007/13.

46 Livestock::FatteningPigs::Housing::Type

Agrammon Group – 13-11-09

46.1 Short description

Selects the emission rate and other correciton factors for the specific housing types for fattening pigs.

46.2 Input parameters

46.3 Technical parameters

46.4 Output

Parameter	Unit	Formula
housing_type	-	Housing type (needed in other modules). In(housing_type);
share_liquid	-	Liquid share for the housing type. Val(share_liquid, 'Type::' . In(housing_type));
er_housing	-	Emission rate for the housing type. Val(er_housing, 'Type::' . In(housing_type));
share_solid	-	Solid share for the housing type. Val(share_solid, 'Type::' . In(housing_type));

46.5 Detailed process description

This process selects the correction factor for the specific housing types for fattening pigs. Among these correction factors are the emission rate for the housing type, the correction factor for the housing type area, the correction factor for the area per animal, the liquid and solid share for the housing type as well as the factor on what barn size increases the regularized minimal (limited to 0.5).

47 Livestock::FatteningPigs::Housing::Type::Deep_Litter

Agrammon Group – 13-11-09

47.1 Short description

Describes correction factors for the label deep litter fattening pig housing system.

47.2 Input parameters

47.3 Technical parameters

47.4 Output

Parameter	Unit	Formula
share_liquid	-	Liquid part of Ntot for selected housing type. Tech(share_liquid);
er_housing	-	Emission rate for specific housing type. Tech(er);
share_solid	-	Solid part of Ntot for selected housing type. 1-Tech(share_liquid);

47.5 Detailed process description

This process describes the correction factors for the label deep litter fattening pig housing system such as the housing specific emission rate, the liquid share and solid share.

48 Livestock::FatteningPigs::Housing::Type::Outdoor

Agrammon Group – 13-11-09

48.1 Short description

Describes emission rates for outdoor fattening pigs. Outdoor fattening pics do not have any housing emissions.

48.2 Input parameters

48.3 Technical parameters

48.4 Output

Parameter	Unit	Formula
share_liquid	-	Liquid part of Ntot for selected housing type. Tech(share_liquid);
er_housing	-	Emission rate for specific housing type. Tech(er);
share_solid	-	For the outdoor fattening pigs 0% of the manure goes into the solid fraction for storage/application. 0

48.5 Detailed process description

This process describes the correction factors for outdoor fattening pigs such as the housing specific emission rate, the liquid share and solid share. Outodoor fattening pigs do not have any housing emissions, as everything is excreted on pasture.

49 Livestock::FatteningPigs::Housing::Type::Slurry_Conventional

Agrammon Group – 13-11-09

49.1 Short description

Describes correction factors for the conventional slurry fattening pig housing system.

49.2 Input parameters

49.3 Technical parameters

49.4 Output

Parameter	Unit	Formula
share_liquid	-	Liquid part of Ntot for selected housing type. Tech(share_liquid);
er_housing	-	Emission rate for specific housing type. Tech(er);
share_solid	-	Solid part of Ntot for selected housing type. 1-Tech(share_liquid);

49.5 Detailed process description

This process describes the correction factors for the conventional slurry fattening pig housing system such as the housing specific emission rate, the liquid share and solid share.

50 Livestock::FatteningPigs::Housing::Type::Slurry_Label

Agrammon Group – 13-11-09

50.1 Short description

Describes correction factors for the label slurry fattening pig housing system.

50.2 Input parameters

50.3 Technical parameters

50.4 Output

Parameter	Unit	Formula
share_liquid	-	Liquid part of Ntot for selected housing type. Tech(share_liquid);
er_housing	-	Emission rate for specific housing type. Tech(er);
share_solid	-	Solid part of Ntot for selected housing type. 1-Tech(share_liquid);

50.5 Detailed process description

This process describes the correction factors for the label slurry fattening pig housing system such as the housing specific emission rate, the liquid share and solid share.

51 Livestock::FatteningPigs::Housing::UNECEhousingTask

Agrammon Group – 13-11-09

51.1 Short description

Computes the annual NH3 reduction due to UNECE housing tasks.

51.2 Input parameters

51.3 Technical parameters

51.4 Output

Parameter	Unit	Formula

c_UNECE_housing_task	-	Reduction factor for the emission due to UNECE housing systems tasks for fully and partly slatted floors.
		
		if (In('UNECE_category_1_mitigation_options_for_housing_systems_for_fattening_pigs') eq "with_scraper_concrete_slats"){
		return Tech('red_PSF_with_scraper_concrete_slats');
		}
		elsif(In('UNECE_category_1_mitigation_options_for_housing_systems_for_fattening_pigs') eq "with_flush_channels_no_areation"){
		return Tech('red_PSF_with_flush_channels_no_areation');
		}
		elsif(In('UNECE_category_1_mitigation_options_for_housing_systems_for_fattening_pigs') eq "with_flush_channels_areation"){
		return Tech('red_PSF_with_flush_channels_areation');
		}
		elsif(In('UNECE_category_1_mitigation_options_for_housing_systems_for_fattening_pigs') eq "with_flush_gutters_tubes_no_areation"){
		return Tech('red_PSF_with_flush_gutters_tubes_no_areation');
		}
		elsif(In('UNECE_category_1_mitigation_options_for_housing_systems_for_fattening_pigs') eq "with_flush_gutters_tubes_areation"){
		return Tech('red_PSF_with_flush_gutters_tubes_areation');
		}
		elsif(In('UNECE_category_1_mitigation_options_for_housing_systems_for_fattening_pigs') eq "with_channels_slanted_walls_concrete_slats"){
		return Tech('red_PSF_with_channels_slanted_walls_concrete_slats');
		}
		elsif(In('UNECE_category_1_mitigation_options_for_housing_systems_for_fattening_pigs') eq "with_channel_slanted_walls_metal_slats"){
		return Tech('red_PSF_with_channel_slanted_walls_metal_slats');
		}
		elsif(In('UNECE_category_1_mitigation_options_for_housing_systems_for_fattening_pigs') eq "with_scraper_metal_slats"){
		return Tech('red_PSF_with_with_scraper_metal_slats');
		}
		elsif(In('UNECE_category_1_mitigation_options_for_housing_systems_for_fattening_pigs') eq "none"){
		return 0;
		};

51.5 Detailed process description

This submodul calculates the annual NH3 reduction due to an air exhaust scrubber in fattening pig housing systems according to the UNECE guideline 2007.

51.5.1 References:

UNECE 2007. Guidance document on control techniques for preventing and abating emissions of ammonia. ECE/EB.AIR/WG.5/2007/13.

52 Livestock::OtherCattle

Agrammon Group – 13-11-09

52.1 Short description

Collects the annual emission of NH3 and the N flux for cattle (apart from dairy cows).

52.2 Input parameters

52.3 Technical parameters

52.4 Output

Parameter	Unit	Formula
nh3_ncattle	kg N /a	Annual NH3 emission from cattle housing, yard and grazing (production). Val(nh3_nhousing, OtherCattle::Housing) + Val(nh3_nyard, OtherCattle::Yard) + Val(nh3_ngrazing, OtherCattle::Grazing);
tan_solid_from_cattle	kg N /a	Annual N flux as TAN from cattle housing and yard, solid fraction. Val(tan_outhousing_solid, OtherCattle::Housing) + Val(tan_outyard_solid, OtherCattle::Yard);
tan_from_cattle	kg N /a	Annnual N flux as TAN from cattle housing and yard. Val(tan_outhousing, OtherCattle::Housing) + Val(tan_outyard, OtherCattle::Yard);
tan_liquid_from_cattle	kg N /a	Annual N flux as TAN from cattle housing and yard, liquid fraction. Val(tan_outhousing_liquid, OtherCattle::Housing) + Val(tan_outyard_liquid, OtherCattle::Yard);
n_excretion	kg N /a	Annual N excreted by cattle. Val(n_excretion, OtherCattle::Excretion);
n_liquid_from_cattle	kg N /a	Annual N flux from cattle housing and yard, liquid fraction. Val(n_outhousing_liquid, OtherCattle::Housing) + Val(n_outyard_liquid, OtherCattle::Yard);
n_solid_from_cattle	kg N /a	Annual N flux from cattle housing and yard, solid fraction. Val(n_outhousing_solid, OtherCattle::Housing) + Val(n_outyard_solid, OtherCattle::Yard);
n_from_cattle	kg N /a	Annual N flux from cattle housing and yard. Val(n_outhousing, OtherCattle::Housing) + Val(n_outyard, OtherCattle::Yard);

52.5 Detailed process description

This process summarizes the annual emission of NH3 for cattle (apart from dairy cows) from housing, yard and grazing. Further it summarizes the annual N flux from housing and yard to the storage for cattle.

53 Livestock::OtherCattle::Excretion

Agrammon Group – 13-11-09

53.1 Short description

Computes the annual N excretion of cattle (apart from dairy cows) as a function of the feed ration.

53.2 Input parameters

53.3 Technical parameters

53.4 Output

Parameter	Unit	Formula
n_sol_excretion	kg N /a	Annual soluble N excreted by an animalgroup of selected cattle category. Out(share_Nsol) × Out(n_excretion);
n_excretion_animal	kg N /a	Annual mean total N excreted of an animal of selected cattle category. Out(standard_N_excretion);

standard_N_excretion	kg N /a	Annual standard N excretion for specified animal category according to Flisch et al. (2009).
		
		my $key = "standard_N_excretion_" . In('animalcategory');
		return Tech($key);

animals	-	Number of animals for the selected cattle category in barn. In(animals);
n_excretion	kg N /a	Annual total N excreted by an animalgroup of selected cattle category. Out(standard_N_excretion) × In(animals);

share_Nsol	-	Nsol content of excreta for a specific cattle category. Derived from e.g. Peterson et al. (1998) or Burgos et al. (2005).
		
		my $key = "share_Nsol_" . In('animalcategory');
		return Tech($key);

53.5 Detailed process description

This process calculates the annual N excretion of a number of cattle as a function of the supplied feed ration. The standard N excretion was taken from the official Swiss fertilizer guidelines. The Nsol content of the excreta is based on e.g. Peterson et al. (1998) or Burgos et al. (2005). These values were compiled on the basis of official feeding recommendations (Flisch et al. 2009) by H. Menzi. A detailed documentation will be prepared in the framework of the new revision of the document in the course of summer 2007.

53.5.1 References:

Burgos SA, Robinson PH, Fadel JG, DePeters EJ 2005. Ammonia volatilization potential: Prediction of urinary urea nitrogen output on lactating dairy cows. Agriculture, Ecosystems and Environment 111:261-269.

Peterson SO, Sommer SG, Aaes O, Soegaard K 1998. Ammonia losses from urine and dung of grazing cattle: effect of N intake. Atmospheric environment 32:295-300.

Flisch R, Sinaj S, Charles R, Richner W 2009. Grundlagen für die die Düngung im Acker- und Futterbau. Agrarforschung 16(2).

54 Livestock::OtherCattle::Grazing

Agrammon Group – 13-11-09

54.1 Short description

Computes the annual NH3 emission from grazing cattle.

54.2 Input parameters

54.3 Technical parameters

54.4 Output

Parameter	Unit	Formula
grazing_days	d /a	Grazing days per year. In(grazing_days);
nh3_ngrazing	kg N /a	Annual NH3 emission from all grazing cattle. Out(n_sol_into_grazing) × Tech(er_cattle_grazing);
n_into_grazing	kg N /a	Annual N excretion during grazing for a defined cattle category. Val(n_excretion, Excretion) × In(grazing_days) / 365 × In(grazing_hours) / 24;
n_remain_pasture	kg N /a	Annual N input on pastures. Out(n_into_grazing) - Out(nh3_ngrazing);

nh3_ngrazing_animal	kg N /a	Annual NH3 emission per cattle form grazing.
		
		if(Val(animals, Excretion) != 0){
		return Out(nh3_ngrazing) / Val(animals, Excretion);
		} else { return 0;};

n_sol_into_grazing	kg N /a	Annual soluble N (TAN) excretion during grazing for a defined cattle category. Val(n_sol_excretion, Excretion) × In(grazing_days) / 365 × In(grazing_hours) / 24;
grazing_hours	h /d	Grazing hours per day. In(grazing_hours);

54.5 Detailed process description

This process calculates the annual NH3 emission from grazing cattle based on the total N excreted on the pastures. The N excreted is calculated according to the time the animals spend on the pasture. It assumes that the excretions on the pasture are proportional to the time the animals are grazed.

54.5.1 References:

Bussink DW 1992. Ammonia volatilization from grassland receiving nitrogen fertilizer and rotationally grazed by dairy cattle. Fertilizer Research 33:257-265.

Bussink DW 1994. Relationship between ammonia volatilization and nitrogen fertilizer application rate, intake and excretion of herbage nitrogen by cattle on grazed swards. Fertilizer Research 38:111-121.

Jarvis SC, Hatch DJ, Lockyer DR 1989. Ammonia fluxes from grazed grassland: annual losses from cattle production systems and their relation to nitrogen inputs. Journal of Agricultural Science 113:99-108.

Peterson SO, Sommer SG, Aaes O, Soegaard K 1998. Ammonia losses from urine and dung of grazing cattle: effect of N intake. Atmospheric environment 32:295-300.

Ross CA, Jarvis SC 2001. Measurement of emission and deposition pattern of ammonia from urine in grass swards. Atmospheric environment 35:867-875.

55 Livestock::OtherCattle::Housing

Agrammon Group – 13-11-09

55.1 Short description

Computes the annual NH3 emission from cattle housing systems.

55.2 Input parameters

55.3 Technical parameters

55.4 Output

Parameter	Unit	Formula
tan_outhousing_liquid	kg N /a	Annual N flux as TAN out of housing, slurry or liquid fraction from cattle. Out(n_outhousing) × Val(share_liquid, Housing::Type) × Out(share_tan_out);
n_outhousing_liquid	kg N /a	Annual N flux out of housing, slurry or liquid fraction from cattle. Out(n_outhousing) × Val(share_liquid, Housing::Type);
n_outhousing	kg N /a	Annual N flux out of housing. Out(n_into_housing) - Out(nh3_nhousing);
n_into_housing	kg N /a	Annual N flux into the house. Val(n_excretion, Excretion) - Val(n_into_grazing, Grazing) - Val(n_into_yard, Yard);
tan_outhousing	kg N /a	Annual N flux as TAN out of housing. Out(n_sol_into_housing) - Out(nh3_nhousing);
nh3_nhousing	kg N /a	Annual NH3 emission from cattle housing systems per animal place. Val(n_sol_excretion, Excretion) × Val(k_grazing, Housing::KGrazing) × Val(er_housing, Housing::Type) × Val(k_area, Housing::Type) × Val(c_UNECE, Housing::Floor);
n_sol_into_housing	kg N /a	Annual N flux as TAN into the house. Val(n_sol_excretion, Excretion) - Val(n_sol_into_grazing, Grazing) - Val(n_sol_into_yard, Yard);
tan_outhousing_solid	kg N /a	Annual N flux as TAN out of housing, solid manure fraction of N flux. Out(n_outhousing) × (1 - Val(share_liquid, Housing::Type)) × Out(share_tan_out);
n_outhousing_solid	kg N /a	Annual N flux out of housing, solid manure fraction of N flux. Out(n_outhousing) × (1 - Val(share_liquid, Housing::Type));
share_tan_out	-	Share of TAN for interface to storage, the same share is assumed for solid and liquid parts of output. Mineralization and immobilization are considerd in the storage module. if(Out(n_outhousing) != 0){ Out(tan_outhousing) / Out(n_outhousing) }else{0};

55.5 Detailed process description

This process calculates the NH3 emission in cattle housing depending on the N excretion and the housing systems. The NH3 emission is assumed to be proportional to the total N excretion of the animals because the contaminated surfaces will primarily drive emission, which will remain active even when animals are on the pasture or exercise yard.

A proportional correction is applied according to the area per animal.

A correction is applied if the part of the day grazing is above a defined grazing hours per days.

55.5.1 Definition of System boundaries for the housing Process:

For housing systems with integrated exercise yards, it is difficult to distinguish between emissions from housing, exercise yard and storage. For these housingtypes the emission may be only validated for the sum of housing, exercise yard and storage emission.

56 Livestock::OtherCattle::Housing::Floor

Agrammon Group – 13-11-09

56.1 Short description

Computes the annual NH3 reduction due to a grooved floor in cattle housing systems.

56.2 Input parameters

56.3 Technical parameters

56.4 Output

Parameter	Unit	Formula

c_UNECE	-	Reduction factor for the emission due to the use of a grooved floor in housing systems.
		
		if (In('UNECE_category_1_mitigation_options_for_housing_systems_for_other_cattle') eq 'toothed_scrapper_running_over_a_grooved_floor'){
		return (1 - Tech('red_UNECE'));
		} else { return 1;};

56.5 Detailed process description

This submodul calculates the annual NH3 reduction due to a grooved floor in cattle housing systems according to the UNECE guideline 2007.

56.5.1 References

UNECE 2007. Guidance document on control techniques for preventing and abating emissions of ammonia. ECE/EB.AIR/WG.5/2007/13.

57 Livestock::OtherCattle::Housing::KGrazing

Agrammon Group – 13-11-09

57.1 Short description

Computes the correction factor for the reduction of the housing emission if the number of grazing hours per day does increase a specific limit.

57.2 Input parameters

57.3 Technical parameters

57.4 Output

Parameter	Unit	Formula

k_grazing	1	The correction factor for the reduction of the housing emission depending on the number of grazing hours per day and the grazing days per year.
		
		if (Val('grazing_hours', '..::Grazing') < 5){
		return ((365.0-Val('grazing_days', '..::Grazing')) +
		((1-Tech(k_grazing_reduction_lw5h))×Val('grazing_days', '..::Grazing'))) /
		365.0 ;
		}
		elsif (Val('grazing_hours', '..::Grazing') < 12.0){
		return ((365.0-Val('grazing_days', '..::Grazing')) +
		((1-Tech(k_grazing_reduction_lw12h))×Val('grazing_days', '..::Grazing'))) /
		365.0 ;
		}
		elsif (Val('grazing_hours', '..::Grazing') < 22.0) {
		return ((365.0-Val('grazing_days', '..::Grazing')) +
		((1-Tech(k_grazing_reduction_lw22h))×Val('grazing_days', '..::Grazing'))) /
		365.0 ;
		}
		elsif (Val('grazing_hours', '..::Grazing') ≥ 22.0) {
		return ((365.0-Val('grazing_days', '..::Grazing')) +
		((1-Tech(k_grazing_reduction_gt22h))×Val('grazing_days', '..::Grazing'))) /
		365.0 ;
		}
		else {
		return 1; # no correction
		};

57.5 Detailed process description

This process calculates the correction factor for the non proportional change of the housing emissions according to the grazing hours per day (Webb et al. 2005). It is based on an empirical estimation of Menzi and Katz (1997). The concept has been lately supported by measurements in the UK (Defra 2005), where reductions comparable to those assumed by Menzi and Katz (1997) were reported.

57.5.1 References:

Department for Environment, Food & Rural Affairs, Defra 2002. Ammonia in the UK. DEFRA Publications, London. Menzi H, Katz PE 1997. A differentiated approach to calculate ammonia emissions from animal husbandry. In: Voermans JAM and Monteny GJ (Eds): "Ammonia and odour emissions from animal production facilities", Proc. International Symposium, Vinkeloord, NL, 6-10 October 1997, 35-42. Webb J, Misselbrook TH 2005. A mass-flow model of ammonia emissions from UK livestock production. Atmospheric environment 38: 2163-2176.

58 Livestock::OtherCattle::Housing::Type

Agrammon Group – 13-11-09

58.1 Short description

Selects the emission rate and other correction factors for the specific housing types for cattle.

58.2 Input parameters

58.3 Technical parameters

58.4 Output

Parameter	Unit	Formula
housing_type	-	Housing type (needed in other modules). In('housing_type');

area_increase	-	Factor on what barn size does increase the regularized minimal, limited to 0.5
		
		if((Val('animals', '..::Excretion') < In('dimensioning_barn')) and (Val('animals', '..::Excretion') != 0)){
		if(In('dimensioning_barn') ≥ (Val(animals, '..::Excretion') × 1.5)){
		return 0.5;
		}
		else {
		return((In('dimensioning_barn') / Val(animals, '..::Excretion')) -1);
		}
		}
		else {
		return 0.0;
		};

share_liquid	-	Liquid share for the housing type. Val(share_liquid, 'Type::' . In('housing_type'));
er_housing	-	Emission rate for the housing type. Val('er_housing', 'Type::' . In('housing_type'));
k_area_type	-	Correction factor for the housing type area. Val('k_area', 'Type::' . In('housing_type'));
share_solid	-	Solid share for the housing type. Val(share_solid, 'Type::' . In('housing_type'));
k_area	-	Correction factor for area per animal. 1 + (Out(area_increase) × Out(k_area_type));

58.5 Detailed process description

This process selects the correction factor for the specific housing types for cattle. Among these correction factors are the emission rate for the housing type, the correction factor for the housing type area, the correction factor for the area per animal, the liquid and solid share for the housing type as well as the factor on what barn size increases the regularized minimal (limited to 0.5).

59 LIVESTOCK::OTHERCATTLE::HOUSING::TYPE::LOOSE_HOUSING_DEEP_LITTER

59 Livestock::OtherCattle::Housing::Type::Loose_Housing_Deep-_Litter

Agrammon Group – 13-11-09

59.1 Short description

Describes correction factors for the loose housing deep litter system.

59.2 Input parameters

59.3 Technical parameters

59.4 Output

Parameter	Unit	Formula
share_liquid	-	Part of Ntot flowing into liquid storage for selected housing type. Tech(share_liquid);
er_housing	-	Emission rate for specific housing type. Tech(er);
share_solid	-	Share of solid manure of Ntot for selected housing type. 1-Tech(share_liquid);
k_area	-	Correction factor for area per animal. Tech(k_area);

59.5 Detailed process description

This process describes the correction factors for the loose housing deep litter system such as the housing specific emission rate, the area per animal correction, the liquid share and solid share.

59.5.1 References:

UNECE 2007. Guidance document on control techniques for preventing and abating emissions of ammonia. UNECE executive body for the convention on long-range transboundary air pollution, Working Group on Strategies and Review, EB.AIR/WH.5/2007/13/ 16 July 2007, Genf. 35p.

60 Livestock::OtherCattle::Housing::Type::Loose_Housing_Slurry

Agrammon Group – 13-11-09

60.1 Short description

Describes correction factors for the loose housing slurry system.

60.2 Input parameters

60.3 Technical parameters

60.4 Output

Parameter	Unit	Formula
share_liquid	-	Part of Ntot flowing into liquid storage for selected housing type. Tech(share_liquid);
er_housing	-	Emission rate for specific housing type. Tech(er);
share_solid	-	Share of solid manure of Ntot for selected housing type. 1-Tech(share_liquid);
k_area	-	Correction factor for area per animal. Tech(k_area);

60.5 Detailed process description

This process describes the correction factors for the loose housing slurry system such as the housing specific emission rate, the area per animal correction, the liquid share and solid share.

60.5.1 References:

UNECE 2007. Guidance document on control techniques for preventing and abating emissions of ammonia. UNECE executive body for the convention on long-range transboundary air pollution, Working Group on Strategies and Review, EB.AIR/WH.5/2007/13/ 16 July 2007, Genf. 35p.

61 Livestock::OtherCattle::Housing::Type::Loose_Housing_Slurry-_Plus_Solid_Manure

Agrammon Group – 13-11-09

61.1 Short description

Describes correction factors for the loose housing liquid solid system.

61.2 Input parameters

61.3 Technical parameters

61.4 Output

Parameter	Unit	Formula
share_liquid	-	Part of Ntot flowing into liquid storage for selected housing type. Tech(share_liquid),
er_housing	-	Emission rate for specific housing type. Tech(er),
share_solid	-	Share of solid manure of Ntot for selected housing type. 1-Tech(share_liquid);
k_area	-	Correction factor for area per animal. Tech(k_area);

61.5 Detailed process description

This process describes the correction factors for the loose housing liquid solid system such as the housing specific emission rate, the area per animal correction, the liquid share and solid share.

61.5.1 References:

UNECE 2007. Guidance document on control techniques for preventing and abating emissions of ammonia. UNECE executive body for the convention on long-range transboundary air pollution, Working Group on Strategies and Review, EB.AIR/WH.5/2007/13/ 16 July 2007, Genf. 35p.

62 Livestock::OtherCattle::Housing::Type::Tied_Housing_Slurry

Agrammon Group – 13-11-09

62.1 Short description

Describes correction factors for the tide housing slurry system.

62.2 Input parameters

62.3 Technical parameters

62.4 Output

Parameter	Unit	Formula
share_liquid	-	Part of Ntot flowing into liquid storage for selected housing type. Tech(share_liquid);
er_housing	-	Emission rate for specific housing type. Tech(er);
share_solid	-	Share of solid manure of Ntot for selected housing type. 1-Tech(share_liquid);
k_area	-	Correction factor for area per animal. Tech(k_area);

62.5 Detailed process description

This process describes the correction factors for the tied housing slurry system such as the housing specific emission rate, the area per animal correction, the liquid share and solid share.

63 Livestock::OtherCattle::Housing::Type::Tied_Housing_Slurry-_Plus_Solid_Manure

Agrammon Group – 13-11-09

63.1 Short description

Describes correciton factors for the tide housing liquid solid system.

63.2 Input parameters

63.3 Technical parameters

63.4 Output

Parameter	Unit	Formula
share_liquid	-	Part of Ntot flowing into liquid storage for selected housing type. Tech(share_liquid);
er_housing	-	Emission rate for specific housing type. Tech(er);
share_solid	-	Share of solid manure of Ntot for selected housing type. 1-Tech(share_liquid);
k_area	-	Correction factor for area per animal. Tech(k_area);

63.5 Detailed process description

This process describes the correction factors for the tied housing liquid solid system such as the housing specific emission rate, the area per animal correction, the liquid share and solid share.

64 Livestock::OtherCattle::Yard

Agrammon Group – 13-11-09

64.1 Short description

Computes the annual NH3 emission from cattle (apart from dairy cows) on exercise yards. Based on the access time and if the the basic feeding is on the yard.

64.2 Input parameters

64.3 Technical parameters

64.4 Output

Parameter	Unit	Formula
n_into_yard	kg N /a	Annual N excretion on yard for a defined animal category. Val('n_excretion', Excretion) × In('yard_days') / 365 × Out(share_excretion_yard);
tan_outyard_solid	kg N /a	Annual N flux as TAN from solid part out of yard into storage. 0;

nh3_nyard_animal	kg N /a	Annual NH3 emission per anmimal from yard.
		
		if(Val('animals', Excretion) != 0){
		return Out('nh3_nyard') / Val('animals', Excretion);
		} else { return 0;};

share_excretion_yard	-	Share of excretion on the yard according the stay on yard. If the basic feeding is on the yard the share_basicfeeding is assumed. Otherwise the share is selected according to the access.
		
		if(In('exercise_yard') eq 'available_roughage_is_not_supplied_in_the_exercise_yard')
		{
		return Tech('share_available_roughage_is_not_supplied_in_the_exercise_yard');
		} elsif(In('exercise_yard') eq 'available_roughage_is_partly_supplied_in_the_exercise_yard') {
		return Tech('share_available_roughage_is_partly_supplied_in_the_exercise_yard');
		} elsif(In('exercise_yard') eq 'available_roughage_is_exclusively_supplied_in_the_exercise_yard') {
		return Tech('share_available_roughage_is_exclusively_supplied_in_the_exercise_yard');
		} elsif(In('exercise_yard') eq 'not_available') {
		return 0;
		};

nh3_nyard	kg N /a	Annual NH3 emission from yard. Out('n_sol_into_yard') × Tech(er_yard) ×(1 - (Out('c_floor_properties_exercise_yard')));
n_outyard	kg N /a	Annual N flux out of yard. Out('n_into_yard') - Out('nh3_nyard');
n_sol_into_yard	kg N /a	Annual soluble N excretion on yard for a defined animal category. Val('n_sol_excretion', Excretion) × In('yard_days') / 365 × Out(share_excretion_yard);
n_outyard_liquid	kg N /a	Annual N flux form liquid part out of yard. Out('n_into_yard') - Out('nh3_nyard');
n_outyard_solid	kg N /a	Annual N flux from solid part out of yard. 0;

tan_outyard_liquid	kg N /a	Annual N flux as TAN from liquid part out of yard into storage. Out('n_sol_into_yard') - Out('nh3_nyard');
tan_outyard	kg N /a	Annual N flux as TAN out of yard into storage. Out('n_sol_into_yard') - Out('nh3_nyard');

c_floor_properties_exercise_yard	-	Reduction factor for the emission due to the use of the floor properties in housing systems.
		
		if (In('floor_properties_exercise_yard') eq 'solid_floor'){
		return Tech('red_floor_properties_solid_floor');
		} elsif (In('floor_properties_exercise_yard') eq 'unpaved_floor'){
		return Tech('red_floor_properties_unpaved_floor');
		} elsif (In('floor_properties_exercise_yard') eq 'perforated_floor'){
		return Tech('red_floor_properties_perforated_floor');
		} elsif (In('floor_properties_exercise_yard') eq 'paddock_or_pasture_used_as_exercise_yard'){
		return Tech('red_floor_properties_paddock_or_pasture_used_as_exercise_yard');
		} else{ return 0;};

64.5 Detailed process description

65 Livestock::Pig

Agrammon Group – 13-11-09

65.1 Short description

Collects the annual emission of NH3 and the N flux for pigs.

65.2 Input parameters

65.3 Technical parameters

65.4 Output

Parameter	Unit	Formula
n_solid_from_pig	kg N /a	Annual N flux from pigs housing, solid fraction. Val(n_outhousing_solid, Pig::Housing);
n_from_pig	kg N /a	Annual N flux from pigs housing. Val(n_outhousing, Pig::Housing);
n_liquid_from_pig	kg N /a	Annual N flux from pigs housing, liquid fraction. Val(n_outhousing_liquid, Pig::Housing);
nh3_npig	kg N /a	Annual NH3 emission from pigs housing and grazing (production). Val(nh3_nhousing, Pig::Housing) + Val(nh3_ngrazing, Pig::Grazing);
tan_from_pig	kg N /a	Annual N flux as TAN from pigs housing. Val(tan_outhousing, Pig::Housing);
tan_liquid_from_pig	kg N /a	Annual N flux as TAN from pigs housing, liquid fraction. Val(tan_outhousing_liquid, Pig::Housing);
tan_solid_from_pig	kg N /a	Annual N flux as TAN from pigs housing, liquid fraction. Val(tan_outhousing_solid, Pig::Housing);
n_excretion	kg N /a	Annual N excreted by pigs. Val(n_excretion, Pig::Excretion);

65.5 Detailed process description

This process summarizes the annual emission of NH3 for pigs from housing and grazing. And it summarizes the annual N flux from housing to the storage for pigs.

66 Livestock::Pig::Excretion

Agrammon Group – 13-11-09

66.1 Short description

Computes the annual N excretion of diffrent pig categories as a function of the crude protein and the energy content of the feed ration.

66.2 Input parameters

66.3 Technical parameters

66.4 Output

Parameter	Unit	Formula
n_sol_excretion	kg N /a	Annual soluble N excreted by a specified number fo pigs. Tech(share_Nsol) × Out(n_excretion);

minimal_N_excretion	kg N /a	Minimal annual N excretion for specified pig category according to Flisch et al. (2009).
		
		my $key = "minimal_N_excretion_" . In('animalcategory');
		return Tech($key);

cfeed	-	Correction factor for feed with reduced crude protein content (BLW, SRVA, LBL 2003).
		
		my $key = "cfeed_" . In('animalcategory');
		return Tech($key);

standard_crude_protein	g CP /kg	Annual standard N excretion for specified pig category according to Flisch et al. (2009).
		
		my $key = "standard_crude_protein_" . In('animalcategory');
		return Tech($key);

pigs	-	Number of pigs of a specific category. In(pigs);

standard_N_excretion	kg N /a	Annual standard N excretion for specified animal category according to Flisch et al. (2009).
		
		my $key = "standard_N_excretion_" . In('animalcategory');
		return Tech($key);

n_excretion	kg N /a	Annual total N excreted by a specified number of animals. if(In('energy_content') != 0){ Out(standard_N_excretion) × (1 - (Out(standard_crude_protein) - In('crude_protein')) × Out(cfeed)) × (Out(standard_energy_content) / In('energy_content')) × In(pigs); } else { ERR "Energy Content can not be 0, use default value!" };

standard_energy_content	MJ VES	Standard energy content of the feed ration for selected pig category.
		
		my $key = "standard_energy_content_" . In('animalcategory');
		return Tech($key);

66.5 Detailed process description

This process calculates the annual N excretion (total N and Nsol) of different pig categories according to the crude protein and energy content of the feed ration.

66.5.1 References:

BLW, SRVA, LBL 2003. Weisungen zur Beruecksichtigung von Ökofuttern in der Suisse-Bilanz. 2003.

Burgos SA, Robinson PH, Fadel JG, DePeters EJ 2005. Ammonia volatilization potential: Prediction of urinary urea nitrogen output on lactating dairy cows. Agriculture, Ecosystems and Environment 111:261-269.

Peterson SO, Sommer SG, Aaes O, Soegaard K 1998. Ammonia losses from urine and dung of grazing cattle: effect of N intake. Atmospheric environment 32:295-300.

Flisch R, Sinaj S, Charles R, Richner W 2009. Grundlagen für die die Düngung im Acker- und Futterbau. Agrarforschung 16(2).

67 Livestock::Pig::Grazing

Agrammon Group – 13-11-09

67.1 Short description

Computes the annual NH3 emission from grazing pigs.

67.2 Input parameters

67.3 Technical parameters

67.4 Output

Parameter	Unit	Formula
nh3_ngrazing	kg N /a	Annual NH3 emission from all pigs from grazing. Out(n_sol_into_grazing) × Tech(er_pig_grazing);

share_grazing	-	Share of N excretion during outdoor activities for a defined animal category. If pig housing type is 'Outdoor' 100% is assumed.
		
		if(Val('housing_type', 'Housing::Type') eq 'Outdoor'){
		return 1;
		}else {
		return 0; # no correction
		};

n_into_grazing	kg N /a	Annual N excretion during grazing for pigs. Val('n_excretion', 'Excretion') × Out(share_grazing);
n_remain_pasture	kg N /a	Annual N input on pastures. Out(n_into_grazing) - Out(nh3_ngrazing);
n_sol_into_grazing	kg N /a	Annual soluble N (TAN) excretion during grazing for pigs. Val('n_sol_excretion', 'Excretion') × Out(share_grazing);

67.5 Detailed process description

This process calculates the annual NH3 emission from grazing pigs based on the N excreted on the pastures. The N excreted is calculated according to the time the animals spend on the pasture. It assumes that the excretions on the pasture are proportional to the time the animals are grazed.

67.5.1 References:

Bussink DW 1992. Ammonia volatilization from grassland receiving nitrogen fertilizer and rotationally grazed by dairy cattle. Fertilizer Research 33:257-265.

Bussink DW 1994. Relationship between ammonia volatilization and nitrogen fertilizer application rate, intake and excretion of herbage nitrogen by cattle on grazed swards. Fertilizer Research 38:111-121.

Flisch R, Sinaj S, Charles R, Richner W 2009. Grundlagen für die die Düngung im Acker- und Futterbau. Agrarforschung 16(2).

Jarvis SC, Hatch DJ, Lockyer DR 1989. Ammonia fluxes from grazed grassland: annual losses from cattle production systems and their relation to nitrogen inputs. Journal of Agricultural Science 113:99-108.

Peterson SO, Sommer SG, Aaes O, Soegaard K 1998. Ammonia losses from urine and dung of grazing cattle: effect of N intake. Atmospheric environment 32:295-300.

Ross CA, Jarvis SC 2001. Measurement of emission and deposition pattern of ammonia from urine in grass swards. Atmospheric environment 35:867-875.

Sommer SG, Sogaard HT, Moller HB, Morsing S 2001. Ammonia volatilization from sows on grassland. Atmospheric environment 35:2023-2032.

68 Livestock::Pig::Housing

Agrammon Group – 13-11-09

68.1 Short description

Computes the annual NH3 emission from pig housing systems.

68.2 Input parameters

68.3 Technical parameters

68.4 Output

Parameter	Unit	Formula
n_housing_filter	kg N /a	Annual N of NH3 emission remaining in air scrubber from pig housing systems. Val('n_sol_excretion', 'Excretion') × Val('er_housing', 'Housing::Type') × (1 - Val('c_air_scrubber', 'Housing::AirScrubber')) × (1 - Val('c_UNECE_housing_task', 'Housing::UNECEhousingTask'));

tan_outhousing_liquid	kg N /a	Annual N flux as TAN out of housing, slurry or liquid fraction from pigs.
		
		if(Val(housing_type, Housing::Type) eq 'Outdoor'){
		0
		}else {
		Out(n_outhousing) × Val('share_liquid', 'Housing::Type') × Out(share_tan_out)
		};

n_outhousing_liquid	kg N /a	Annual N flux out of housing, slurry or liquid fraction from pigs.
		
		if(Val(housing_type, Housing::Type) eq 'Outdoor'){
		0
		}else {
		Out(n_outhousing) × Val('share_liquid', 'Housing::Type')
		};

n_outhousing	kg N /a	Annual N flux out of the housing including N remained in biotrickling filter.
		
		if(Val('housing_type', 'Housing::Type') eq 'Outdoor'){
		0
		}else {
		if(Val('air_scrubber', 'Housing::AirScrubber') eq 'acid'){
		Out(n_into_housing) - Out(nh3_nhousing) - Out(n_housing_filter)
		}else{
		Out(n_into_housing) - Out(nh3_nhousing)
		};
		};

n_into_housing	kg N /a	Annual N flux into the house. Val('n_excretion', 'Excretion') - Val('n_into_grazing', 'Grazing');

tan_outhousing	kg N /a	Annual N flux as TAN out of the housing indcluding N remained in biotrickling filter. (without remains from acid filter)
		
		if(Val(housing_type, Housing::Type) eq 'Outdoor'){
		0
		}else {
		if(Val('air_scrubber', 'Housing::AirScrubber') eq 'acid'){
		Out(n_into_housing) - Out(nh3_nhousing) - Out(n_housing_filter)
		}else{
		Out(n_sol_into_housing) - Out(nh3_nhousing)
		};
		};

nh3_nhousing	kg N /a	Annual NH3 emission from pig housing systems. Val('n_sol_excretion', 'Excretion') × Val('er_housing', 'Housing::Type') × Val('c_air_scrubber', 'Housing::AirScrubber') × (1 - Val('c_UNECE_housing_task', 'Housing::UNECEhousingTask'));
n_sol_into_housing	kg N /a	Annual N flux as TAN into the house. Val('n_sol_excretion', 'Excretion') - Val('n_sol_into_grazing', 'Grazing');

tan_outhousing_solid	kg N /a	Annual N flux as TAN out of housing, manure fraction of N flux from pigs.
		
		if(Val(housing_type, Housing::Type) eq 'Outdoor'){
		0
		}else {
		Out(n_outhousing) × (1 - Val('share_liquid', 'Housing::Type')) × Out(share_tan_out)
		};

n_outhousing_solid	kg N /a	Annual N flux out of housing, manure fraction of N flux from pigs.
		
		if(Val('housing_type', 'Housing::Type') eq 'Outdoor'){
		0
		}else {
		Out(n_outhousing) × (1 - Val('share_liquid', 'Housing::Type'))
		};

share_tan_out	-	Share of TAN for interface to storage, the same share is assumed for solid and liquid parts of output. Mineralization and immobilization are considerd in the storage module. if(Out(n_outhousing) != 0){ Out(tan_outhousing) / Out(n_outhousing) }else{0};

68.5 Detailed process description

This process calculates the NH3 emission in pig housing depending on the N excretion and the housing systems. The NH3 emission is assumed to be proportional to the total N excretion of the animals because the contaminated surfaces will primarily drive emissions, which will remain active even when animals are on the pasture or exercise yard.

A proportional correction is applied according to the area per animal.

A correction is applied if the part of the day grazing is above a defined grazing hours per days.

68.5.1 Definition of System boundaries for the housing Process:

For housing systems with integrated exercise yards, it is difficult to distinguish between emissions from housing, exercise yard and storage. For these housingtypes the emission may be only validated for the sum of housing, exercise yard and storage emission.

69 Livestock::Pig::Housing::AirScrubber

Agrammon Group – 13-11-09

69.1 Short description

Computes the annual NH3 reduction due to an exhaust air scrubber in housing systems.

69.2 Input parameters

69.3 Technical parameters

69.4 Output

Parameter	Unit	Formula
air_scrubber	-	air exhaust scrubber in housing systems. In(air_scrubber);

c_air_scrubber	-	Reduction factor for the emission due to the use of an air exhaust scrubber in housing systems.
		
		if (In('air_scrubber') eq 'acid'){
		return (1 - Tech('red_acid_air_scrubber'));
		} elsif(In('air_scrubber') eq 'biotrickling'){
		return (1 - Tech('red_biotrickling_filter_air_scrubber'));
		} elsif(In('air_scrubber') eq 'none'){
		return 1;
		} else{
		ERR "Invalid 'air_scrubber' defined!";
		return 1;
		}

69.5 Detailed process description

This submodul calculates the annual NH3 reduction due to an exhaust air scrubber in housing systems according to the UNECE guideline 2007.

69.5.1 References:

UNECE 2007. Guidance document on control techniques for preventing and abating emissions of ammonia. ECE/EB.AIR/WG.5/2007/13.

70 Livestock::Pig::Housing::Type

Agrammon Group – 13-11-09

70.1 Short description

Selects the emission rate and other correciton factors for the specific housing types for pigs.

70.2 Input parameters

70.3 Technical parameters

70.4 Output

Parameter	Unit	Formula
housing_type	-	Housing type (needed in other modules). In(housing_type);
share_liquid	-	Liquid share for the housing type. Val(share_liquid, 'Type::' . In(housing_type));
er_housing	-	Emission rate for the housing type. Val(er_housing, 'Type::' . In(housing_type));
share_solid	-	Solid share for the housing type. Val(share_solid, 'Type::' . In(housing_type));

70.5 Detailed process description

This process selects the correction factor for the specific housing types for pigs. Among these correction factors are the emission rate for the housing type, the correction factor for the housing type area, the correction factor for the area per animal, the liquid and solid share for the housing type as well as the factor on what barn size increases the regularized minimal (limited to 0.5).

71 Livestock::Pig::Housing::Type::Deep_Litter

Agrammon Group – 13-11-09

71.1 Short description

Describes correction factors for the label deep litter pig housing system.

71.2 Input parameters

71.3 Technical parameters

71.4 Output

Parameter	Unit	Formula
share_liquid	-	Liquid part of Ntot for selected housing type. Tech(share_liquid);
er_housing	-	Emission rate for specific housing type. Tech(er);
share_solid	-	Solid part of Ntot for selected housing type. 1-Tech(share_liquid);

71.5 Detailed process description

This process describes the correction factors for the label deep litter pig housing system such as the housing specific emission rate, the liquid share and solid share.

72 Livestock::Pig::Housing::Type::Outdoor

Agrammon Group – 13-11-09

72.1 Short description

Describes emission rates for outdoor pigs. Outodoor pigs do not have any housing emissions.

72.2 Input parameters

72.3 Technical parameters

72.4 Output

Parameter	Unit	Formula
share_liquid	-	Liquid part of Ntot for selected housing type. Tech(share_liquid);
er_housing	-	Emission rate for specific housing type. Tech(er);
share_solid	-	For the outdoor pigs 0% of the manure goes into the solid fraction for storage/application. 0

72.5 Detailed process description

This process describes the correction factors for outdoor pigs such as the housing specific emission rate, the liquid share and solid share. Outodoor pigs do not have any housing emissions, as everything is excreted on pasture.

73 Livestock::Pig::Housing::Type::Slurry_Conventional

Agrammon Group – 13-11-09

73.1 Short description

Describes correction factors for the conventional slurry pig housing system.

73.2 Input parameters

73.3 Technical parameters

73.4 Output

Parameter	Unit	Formula
share_liquid	-	Liquid part of Ntot for selected housing type. Tech(share_liquid);
er_housing	-	Emission rate for specific housing type. Tech(er);
share_solid	-	Solid part of Ntot for selected housing type. 1-Tech(share_liquid);

73.5 Detailed process description

This process describes the correction factors for the conventional slurry pig housing system such as the housing specific emission rate, the liquid share and solid share.

74 Livestock::Pig::Housing::Type::Slurry_Label

Agrammon Group – 13-11-09

74.1 Short description

Describes correction factors for the label slurry pig housing system.

74.2 Input parameters

74.3 Technical parameters

74.4 Output

Parameter	Unit	Formula
share_liquid	-	Liquid part of Ntot for selected housing type. Tech(share_liquid);
er_housing	-	Emission rate for specific housing type. Tech(er);
share_solid	-	Solid part of Ntot for selected housing type. 1-Tech(share_liquid);

74.5 Detailed process description

This process describes the correction factors for the label slurry pig housing system such as the housing specific emission rate, the liquid share and solid share.

75 Livestock::Pig::Housing::UNECEhousingTask

Agrammon Group – 13-11-09

75.1 Short description

Computes the annual NH3 reduction due to an exhaust air scrubber in housing systems.

75.2 Input parameters

75.3 Technical parameters

75.4 Output

Parameter	Unit	Formula

c_UNECE_housing_task	-	Reduction factor for the emission due to UNECE housing systems tasks for fully and partly slatted floors.
		
		if (In('UNECE_category_1_mitigation_options_for_housing_systems_for_pigs') eq "with_scraper_concrete_slats"){
		return Tech('red_PSF_with_scraper_concrete_slats');
		}
		elsif(In('UNECE_category_1_mitigation_options_for_housing_systems_for_pigs') eq "with_flush_channels_no_areation"){
		return Tech('red_PSF_with_flush_channels_no_areation');
		}
		elsif(In('UNECE_category_1_mitigation_options_for_housing_systems_for_pigs') eq "with_flush_channels_areation"){
		return Tech('red_PSF_with_flush_channels_areation');
		}
		elsif(In('UNECE_category_1_mitigation_options_for_housing_systems_for_pigs') eq "with_flush_gutters_tubes_no_areation"){
		return Tech('red_PSF_with_flush_gutters_tubes_no_areation');
		}
		elsif(In('UNECE_category_1_mitigation_options_for_housing_systems_for_pigs') eq "with_flush_gutters_tubes_areation"){
		return Tech('red_PSF_with_flush_gutters_tubes_areation');
		}
		elsif(In('UNECE_category_1_mitigation_options_for_housing_systems_for_pigs') eq "with_channels_slanted_walls_concrete_slats"){
		return Tech('red_PSF_with_channels_slanted_walls_concrete_slats');
		}
		elsif(In('UNECE_category_1_mitigation_options_for_housing_systems_for_pigs') eq "with_channel_slanted_walls_metal_slats"){
		return Tech('red_PSF_with_channel_slanted_walls_metal_slats');
		}
		elsif(In('UNECE_category_1_mitigation_options_for_housing_systems_for_pigs') eq "with_scraper_metal_slats"){
		return Tech('red_PSF_with_with_scraper_metal_slats');
		}
		elsif(In('UNECE_category_1_mitigation_options_for_housing_systems_for_pigs') eq "none"){
		return 0;
		};

75.5 Detailed process description

This submodul calculates the annual NH3 reduction due to an exhaust air scrubber in housing systems according to the UNECE guideline 2007.

75.5.1 References:

UNECE 2007. Guidance document on control techniques for preventing and abating emissions of ammonia. ECE/EB.AIR/WG.5/2007/13.

76 Livestock::Poultry

Agrammon Group – 13-11-09

76.1 Short description

Collects the emission of NH3, the N excretion, and the N flux for the diffrent poultry categories per year.

76.2 Input parameters

76.3 Technical parameters

76.4 Output

Parameter	Unit	Formula

n_from_poultry_turkeys-_broilers	kg N /a	Annual N flux from poultry housing.
		
		if(Val('animalcategory',Poultry::Excretion) eq 'turkeys'
		|| Val('animalcategory',Poultry::Excretion) eq 'broilers') {
		Val('n_outhousing', Poultry::Housing);
		}else{
		return(0);
		};

tan_from_poultry_turkeys-_broilers	kg N /a	Annual N flux from poultry housing.
		
		if(Val('animalcategory', Poultry::Excretion) eq 'turkeys'
		|| Val('animalcategory', Poultry::Excretion) eq 'broilers'){
		Val('tan_outhousing', Poultry::Housing);
		}else{
		return(0);
		};

tan_from_poultry_layers-_growers_other_poultry	kg N /a	Annual N flux from poultry housing.
		
		if(Val('animalcategory', Poultry::Excretion) eq 'layers'
		|| Val('animalcategory', Poultry::Excretion) eq 'growers'
		|| Val('animalcategory', Poultry::Excretion) eq 'other_poultry'){
		Val('tan_outhousing', Poultry::Housing);
		}else{
		return(0);
		};

tan_from_poultry	kg N /a	Annual N flux from poultry housing. Val('tan_outhousing', Poultry::Housing);
n_excretion	kg N /a	Annual N excreted by poultry. Val('n_excretion', Poultry::Excretion);
n_from_poultry	kg N /a	Annual N flux from poultry housing. Val('n_outhousing', Poultry::Housing);

n_excretion_turkeys-_broilers	kg N /a	Annual N excreted by poultry.
		
		if(Val('animalcategory', Poultry::Excretion) eq 'turkeys'
		|| Val('animalcategory', Poultry::Excretion) eq 'broilers'){
		Val('n_excretion', Poultry::Excretion);
		}else{
		return(0);
		};

nh3_npoultry_turkeys-_broilers	kg N /a	Annual NH3 emission from poultry production (housing and outdoor).
		
		if(Val('animalcategory', Poultry::Excretion) eq 'turkeys'
		|| Val('animalcategory', Poultry::Excretion) eq 'broilers'){
		Val(nh3_nhousing, Poultry::Housing) +
		Val(nh3_nfree_range, Poultry::Outdoor);
		}else{
		return(0);
		};

n_excretion_layers_growers-_other_poultry	kg N /a	Annual N excreted by poultry.
		
		if (Val('animalcategory', Poultry::Excretion)eq 'layers'
		|| Val('animalcategory', Poultry::Excretion) eq 'growers'
		|| Val('animalcategory', Poultry::Excretion) eq 'other_poultry'){
		Val('n_excretion', Poultry::Excretion);
		}else{
		return(0);
		};

n_from_poultry_layers-_growers_other_poultry	kg N /a	Annual N flux from poultry housing.
		
		if(Val('animalcategory', Poultry::Excretion) eq 'layers'
		|| Val('animalcategory', Poultry::Excretion) eq 'growers'
		|| Val('animalcategory', Poultry::Excretion) eq 'other_poultry'){
		Val('n_outhousing', Poultry::Housing);
		}else{
		return(0);
		};

nh3_npoultry_layers-_growers_other_poultry	kg N /a	Annual NH3 emission from poultry production (housing and outdoor).
		
		if(Val('animalcategory', Poultry::Excretion) eq 'layers'
		|| Val('animalcategory', Poultry::Excretion) eq 'growers'
		|| Val('animalcategory', Poultry::Excretion) eq 'other_poultry'){
		Val(nh3_nhousing, Poultry::Housing) +
		Val(nh3_nfree_range, Poultry::Outdoor);
		}else{
		return(0);
		};

nh3_npoultry	kg N /a	Annual NH3 emission from poultry production (housing and outdoor). Val(nh3_nhousing, Poultry::Housing) + Val(nh3_nfree_range, Poultry::Outdoor);

76.5 Detailed process description

This process summarizes the annual emission of NH_3, the annual N excretion, and the annual N flux for different poultry categories from housing and outdoor.

77 Livestock::Poultry::Excretion

Agrammon Group – 13-11-09

77.1 Short description

Computes the annual N excretion of the different poultry categories.

77.2 Input parameters

Parameter	Unit	Description
animalcategory	-	Poultry category (layers, growers, broilers, turkeys, and other poultry). Possible values: `broilers`, `growers`, `other_poultry`, `turkeys`, `layers`
animals	-	Number of poultry animals for the selected type in barn.

77.3 Technical parameters

Parameter	Value	Unit	Description
standard_N_excretion-_layers	0.80	kg N /a	Annual standard N excretion for poultry category (layers) according to Flisch et al. (2009).
standard_N_excretion-_growers	0.34	kg N /a	Annual standard N excretion for poultry category (growers) according to Flisch et al. (2009).
standard_N_excretion-_broilers	0.45	kg N /a	Annual standard N excretion for poultry category (broilers) according to Flisch et al. (2009).
standard_N_excretion-_turkeys	1.4	kg N /a	Annual standard N excretion for poultry category according (turkeys) to Flisch et al. (2009).
standard_N_excretion-_other_poultry	0.56	kg N /a	Annual standard N excretion for other poultry category according to Flisch et al. (2009).
share_Nsol_layers	0.6	-	Nsol content of excreta for layers. Derived from e.g. TODO
share_Nsol_growers	0.6	-	Nsol content of excreta for growers. Derived from e.g. TODO
share_Nsol_broilers	0.6	-	Nsol content of excreta for broilers. Derived from e.g. TODO
share_Nsol_turkeys	0.6	-	Nsol content of excreta for turkeys. Derived from e.g. TODO
share_Nsol_other_poultry	0.6	-	Nsol content of excreta for other poultry. Derived from e.g. TODO

77.4 Output

Parameter	Unit	Formula
n_sol_excretion	kg N /a	Annual soluble N excreted by an animalgroup of selected poultry category. Out(share_Nsol) × Out(n_excretion)
animalcategory	-	Poultry category (layers, growers, broilers, turkeys, and other poultry). In('animalcategory');

standard_N_excretion	kg N /a	Annual standard N excretion for specified poultry category according to Flisch et al. (2009).
		
		my $key = "standard_N_excretion_" . In('animalcategory');
		return Tech($key);

animals	-	Number of poultry animals for the selected type in barn. In(animals);
n_excretion	kg N /a	Annual N excreted by a specified number of animals. Out(standard_N_excretion) × In(animals);

share_Nsol	-	Nsol content of excreta for a specific poultry category. Derived from e.g. TODO
		
		my $key = "share_Nsol_" . In('animalcategory');
		return Tech($key);

77.5 Detailed process description

This process calculates the annual N excretion of the different poultry categories. The standard N excretion was taken from the official Swiss fertilizer guidelines. The Nsol content of the excreta is based on e.g. Peterson et al. (1998) or Burgos et al. (2005). These values were compiled on the basis of official feeding recommendations (Flisch et al. (2009)) by H. Menzi.

77.5.1 References:

Burgos SA, Robinson PH, Fadel JG, DePeters EJ 2005. Ammonia volatilization potential: Prediction of urinary urea nitrogen output on lactating dairy cows. Agriculture, Ecosystems and Environment 111:261-269.

Peterson SO, Sommer SG, Aaes O, Soegaard K 1998. Ammonia losses from urine and dung of grazing cattle: effect of N intake. Atmospheric environment 32:295-300.

Flisch R, Sinaj S, Charles R, Richner W 2009. Grundlagen für die die Düngung im Acker- und Futterbau. Agrarforschung 16(2).

78 Livestock::Poultry::Housing

Agrammon Group – 13-11-09

78.1 Short description

Computes the NH3 emission, the N flux into the housing and the N flux out of the house from poultry housing per year.

78.2 Input parameters

78.3 Technical parameters

78.4 Output

Parameter	Unit	Formula
n_housing_filter	kg N /a	Annual N of NH3 emission remaining in air scrubber from pig housing systems. Val(n_excretion, Excretion) × Val('er_housing', 'Housing::Type') × Val(c_manure_removal_interval, Housing::Type) × Val(c_drinking_system, Housing::Type) × (1 - Val('c_air_scrubber', 'Housing::AirScrubber'));

n_outhousing	kg N /a	Annual N flux out of the housing including N remained in biotrickling filter.
		
		if(Val('air_scrubber', 'Housing::AirScrubber') eq 'acid'){
		Out(n_into_housing) - Out(nh3_nhousing) - Out(n_housing_filter)
		}else{
		Out(n_into_housing) - Out(nh3_nhousing)
		};

tan_into_housing	kg N /a	Annual N flux into the housing. Val(n_sol_excretion, Excretion) - Val(tan_excr_free_range, Outdoor);
n_into_housing	kg N /a	Annual N flux into the housing. Val(n_excretion, Excretion) - Val(n_excr_free_range, Outdoor);

tan_outhousing	kg N /a	Annual N flux out of the housing including N remained in biotrickling filter.
		
		if(Val('air_scrubber', 'Housing::AirScrubber') eq 'acid'){
		Out(tan_into_housing) - Out(nh3_nhousing) - Out(n_housing_filter)
		}else{
		Out(tan_into_housing) - Out(nh3_nhousing)
		};

nh3_nhousing	kg N /a	Annual NH3 emission from poultry housing systems per animal place. (Val(n_excretion, Excretion) × Val(er_housing, Housing::Type) × Val(c_manure_removal_interval, Housing::Type) × Val(c_drinking_system, Housing::Type) × Val(c_air_scrubber, Housing::AirScrubber));

78.5 Detailed process description

This process calculates the NH3 emission in poultry housing depending on the N excretion and the housing systems. The NH3 emission is assumed to be proportional to the total N excretion of the animals because the contaminated surfaces will primarily drive emissions, which will remain active even when animals are on the pasture or exercise yard.

A proportional correction is applied according to the area per animal.

A correction is applied if the part of the day grazing is above a defined grazing hours per days.

78.5.1 Definition of System boundaries for the housing Process:

For housing systems with integrated exercise yards, it is difficult to distinguish between emissions from housing, exercise yard and storage. For these housingtypes the emission may be only validated for the sum of housing, exercise yard and storage emission.

79 Livestock::Poultry::Housing::AirScrubber

Agrammon Group – 13-11-09

79.1 Short description

Computes the annual NH3 reduction due to an exhaust air scrubber in housing systems.

79.2 Input parameters

Parameter	Unit	Description
air_scrubber	-	Exhaust air scrubber: none, acid, biotrickling_filter. Possible values: `acid`, `biotrickling`, `none`

79.3 Technical parameters

Parameter	Value	Unit	Description
red_acid_air_scrubber	0.9	-	Reduction efficiency as compared to group-housed on fully and partly slatted floors (UNECE 2007, paragraph 71, table 5).
red_biotrickling_filter_air_scrubber	0.7	-	Reduction efficiency as compared to group-housed on fully and partly slatted floors (UNECE 2007, paragraph 71, table 5).

79.4 Output

Parameter	Unit	Formula
air_scrubber	-	air exhaust scrubber in housing systems. In(air_scrubber);

c_air_scrubber	-	Reduction factor for the emission due to the use of an air exhaust scrubber in housing systems.
		if (In('air_scrubber') eq 'acid'){
		return (1 - Tech('red_acid_air_scrubber'));
		} elsif(In('air_scrubber') eq 'biotrickling'){
		return (1 - Tech('red_biotrickling_filter_air_scrubber'));
		} elsif(In('air_scrubber') eq 'none'){
		return 1;
		} else{
		ERR "Invalid 'air_scrubber' defined!";
		return 1;
		}

79.5 Detailed process description

This submodul calculates the annual NH3 reduction due to an exhaust air scrubber in housing systems according to the UNECE guideline 2007.

79.5.1 References:

UNECE 2007. Guidance document on control techniques for preventing and abating emissions of ammonia. ECE/EB.AIR/WG.5/2007/13.

80 Livestock::Poultry::Housing::Type

Agrammon Group – 13-11-09

80.1 Short description

Selects the emission rate and other correction factors for the specific housing types for poultry.

80.2 Input parameters

Parameter	Unit	Description
housing_type	-	Type of housing. Possible values: `deep_litter`, `deep_pit`, `manure_belt`
manure_removal_interval	-	Manure removal interval by manure belt. Possible values: `3_to_4_times_a_month`, `more_than_4_times_a_month`, `no_manure_belt`, `twice_a_month`, `less_than_twice_a_month`
drinking_system	-	Type of drinking system. Possible values: `bell_drinkers`, `drinking_nipples`

80.3 Technical parameters

Parameter	Value	Unit	Description
er_housing_layers_growers-_manure_belt	0.15	-	Emission rate for the poultry housing type, based on EAGER workshop January 2007: 15% of Ntot, converted using 60% Nsol and emission factor of 25%.
er_housing_layers_growers-_deep_pit	0.30	-	Emission rate for the poultry housing type, based on EAGER workshop January 2007, UNECE 2007: 30% of Ntot, converted using 60% Nsol and emission factor of 50%.
er_housing_layers_growers-_deep_litter	0.30	-	Emission rate for the poultry housing type, based on EAGER workshop January 2007, UNECE 2007: 30% of Ntot, converted using 60% Nsol and emission factor of 50%.
er_housing_other_deep-_litter	0.12	-	Emission rate for the poultry housing type, based on Reidy et al. (2009): 12% of Ntot, converted using 60% Nsol and emission factor of 20%.
c_manure_removal_interval-_less_than_twice_a_month	1.2	-	Emission rate for the poultry manure removal by droppings belt. Empirical assumption by Reidy/Menzi.
c_manure_removal_interval-_twice_a_month	1	-	Emission rate for the poultry manure removal by droppings belt. Empirical assumption by Reidy/Menzi.
c_manure_removal_interval-_3_to_4_times_a_month	0.8	-	Emission rate for the poultry manure removal by droppings belt. Empirical assumption by Reidy/Menzi.
c_manure_removal_interval-_more_than_4_times_a-_month	0.6	-	Emission rate for the poultry manure removal by droppings belt. Empirical assumption by Reidy/Menzi.
c_drinking_nipples	1.0	-	Emission rate for the poultry drinking type standard version.
c_bell_drinkers TODO: Give better description!	1.2	-	Emission rate for the poultry drinking type additional emission. Empirical assumption by Reidy/Menzi.

80.4 Output

Parameter	Unit	Formula
housing_type	-	Housing type (needed in other modules). In('housing_type');

er_housing	-	Emission rate for the poultry housing type.
		
		if (Val('animalcategory', '..::Excretion') eq "layers"){
		if (In('housing_type') eq "manure_belt"){
		return Tech('er_housing_layers_growers_manure_belt');
		} elsif(In('housing_type') eq "deep_pit"){
		return Tech('er_housing_layers_growers_deep_pit');
		} elsif(In('housing_type') eq "deep_litter"){
		return Tech('er_housing_layers_growers_deep_litter');
		}
		}
		elsif (Val('animalcategory', '..::Excretion') eq "growers"){
		if (In('housing_type') eq "manure_belt"){
		return Tech('er_housing_layers_growers_manure_belt');
		} elsif(In('housing_type') eq "deep_pit"){
		return Tech('er_housing_layers_growers_deep_pit');
		} elsif(In('housing_type') eq "deep_litter"){
		return Tech('er_housing_layers_growers_deep_litter');
		}
		}
		elsif (Val('animalcategory', '..::Excretion') eq "broilers"){
		if (In('housing_type') eq "manure_belt"){
		ERR "manure_belt not valid, please select deep_litter as housing type for broilers.";
		return Tech('er_housing_other_deep_litter');
		} elsif(In('housing_type') eq "deep_pit"){
		ERR "deep_pit not valid, please select deep_litter as housing type for broilers.";
		return Tech('er_housing_other_deep_litter');
		} elsif(In('housing_type') eq "deep_litter"){
		return Tech('er_housing_other_deep_litter');
		}
		}
		elsif (Val('animalcategory', '..::Excretion') eq "turkeys"){
		if (In('housing_type') eq "manure_belt"){
		ERR "manure_belt not valid, please select deep_litter as housing type for turkeys.";
		return Tech('er_housing_other_deep_litter');
		} elsif(In('housing_type') eq "deep_pit"){
		ERR "deep_pit not valid, please select deep_litter as housing type for turkeys.";
		return Tech('er_housing_other_deep_litter');
		} elsif(In('housing_type') eq "deep_litter"){
		return Tech('er_housing_other_deep_litter');
		}else {
		ERR "Invalid 'manure_removal_interval' defined!";
		return 0;
		}
		}
		elsif (Val('animalcategory', '..::Excretion') eq "other_poultry"){
		if (In('housing_type') eq "manure_belt"){
		ERR "manure_belt not valid, please select deep_litter as housing type for other_poultry.";
		return Tech('er_housing_other_deep_litter');
		} elsif(In('housing_type') eq "deep_pit"){
		ERR "deep_pit not valid, please select deep_litter as housing type for other_poultry.";
		return Tech('er_housing_other_deep_litter');
		} elsif(In('housing_type') eq "deep_litter"){
		return Tech('er_housing_other_deep_litter');
		}else {
		ERR "Invalid 'manure_removal_interval' defined!";
		return 0;
		}
		}

drinking_system	-	Drinking system. In('drinking_system');

c_manure_removal_interval	-	Emission rate for the poultry housing type.
		
		if (In('manure_removal_interval') eq "less_than_twice_a_month"){
		return Tech('c_manure_removal_interval_less_than_twice_a_month');
		} elsif(In('manure_removal_interval') eq "twice_a_month"){
		return Tech('c_manure_removal_interval_twice_a_month');
		} elsif(In('manure_removal_interval') eq "3_to_4_times_a_month"){
		return Tech('c_manure_removal_interval_3_to_4_times_a_month');
		} elsif(In('manure_removal_interval') eq "more_than_4_times_a_month"){
		return Tech('c_manure_removal_interval_more_than_4_times_a_month');
		} elsif(In('manure_removal_interval') eq "no_manure_belt"){
		return 1 ;
		} else {
		ERR "Invalid 'Poultry:housing system' or 'removal interval' defined!";
		return 1;
		}

c_drinking_system	-	Correction factor for poultry drinking station.
		
		if (In('drinking_system') eq "drinking_nipples"){
		return Tech('c_drinking_nipples');
		} elsif(In('drinking_system') eq "bell_drinkers"){
		return Tech('c_bell_drinkers');
		}else {
		ERR "Invalid 'drinking_system' defined!";
		return 1.0;
		}

80.5 Detailed process description

This process selects the emission rate for the specific housing types for poultry and the correction factors for the drinking system, and for the manure removal interval.

80.5.1 References

UNECE 2007. Guidance document on control techniques for preventing and abating emissions of ammonia. ECE/EB.AIR/WG.5/2007/13. Reidy B, Webb J, Misselbrook TH, Menzi H, Luesink HH, Hutchings NJ, Eurich-Menden B, Döhler H, Dämmgen U 2009. Comparison of models used for national agricultural ammonia emission inventories in Europe: litter-based manure systems. Atmospheric Environment 40, 1632-1640.

81 Livestock::Poultry::Outdoor

Agrammon Group – 13-11-09

81.1 Short description

Computes the NH3 emission, the N excretion and the remaining N of free range poultry per year.

81.2 Input parameters

Parameter	Unit	Description
free_range	-	Average free range hours per day. Possible values: `no`, `yes`

81.3 Technical parameters

Parameter	Value	Unit	Description
er_free_range	0.7	-	Emission rate for free range poultry, based on Menzi et al. (1997): 70% of TAN or 28% of Ntot
free_range_days_layers	280	d /a	Average free range days per year.
free_range_hours_layers	2.88	h /d	Average free range hours per day, assumed is 12% of Day
free_range_days_growers	280	d /a	Average free range days per year.
free_range_hours_growers	2.88	h /d	Average free range hours per day, assumed is 12% of Day
free_range_days_turkeys	280	d /a	Average free range days per year.
free_range_hours_turkeys	0.96	h /d	Average free range hours per day, assumed is 4% of Day
free_range_days_other-_poultry	280	d /a	Average free range days per year.
free_range_hours_other-_poultry	0.96	h /d	Average free range hours per day, assumed is 12% of Day
free_range_days_broilers	280	d /a	Average free range days per year.
free_range_hours_broilers	0.96	h /d	Average free range hours per day, assumed is 4% of Day

81.4 Output

Parameter	Unit	Formula
n_remain_free_range	kg N /a	Annual N remaining free_range (on pasture, etc.). Out(n_excr_free_range) - Out(nh3_nfree_range);

free_range_hours	h /d	Average free range hours per day.
		
		if(In('free_range') eq 'yes'){
		my $key = "free_range_hours_" . Val('animalcategory', 'Excretion');
		return Tech($key);
		}else{
		return 0;
		}

nh3_nfree_range	kg N /a	Annual free_range NH3 emission from poultry (grazing). Out(tan_excr_free_range) × Tech(er_free_range);
n_excr_free_range	kg N /a	Annual N excretion free_range (grazing). Val(n_excretion, Excretion) × ((Out(free_range_days)/365) × (Out(free_range_hours)/24));
tan_excr_free_range	kg N /a	Annual N excretion free_range (grazing). Val(n_sol_excretion, Excretion) × ((Out(free_range_days)/365) × (Out(free_range_hours)/24)) ;

free_range_days	d /a	Average free range days per year.
		
		if(In('free_range') eq 'yes'){
		my $key = "free_range_days_" . Val('animalcategory', 'Excretion');
		return Tech($key);
		}else{
		return 0;
		}

81.5 Detailed process description

This process calculates the annual NH3 emission of free range poultry depending on the free range N excretion and the emission rate. The annual N excretion calculation is based on the grazing hours per day per year and the free range hours per day per year. The annual remaining N from free range poultry is calculated as the annual N excretion minus the annual NH3 emission.

81.5.1 References:

Menzi H, Shariatmadari H, Meierhans D, Wiedmer H 1997: Nähr- und Schadstoffbelastung von Geflügelausläufen. Agrarforschung 4: 361-364.

82 Livestock::SmallRuminants

Agrammon Group – 13-11-09

82.1 Short description

Collects the annual emission of NH3 and the N flux for goats, fattening sheep and milksheep.

82.2 Input parameters

82.3 Technical parameters

82.4 Output

Parameter	Unit	Formula
n_from_other	kg N /a	Annual N flux from other animals housing. Val(n_outhousing, SmallRuminants::Housing);
tan_liquid_from_other	kg N /a	Annual N flux as TAN from other animals housing, liquid fraction. Val(tan_outhousing_liquid, SmallRuminants::Housing);
nh3_nother	kg N /a	Annual NH3 emission from other animals housing and grazing. Val(nh3_nhousing, SmallRuminants::Housing) + Val(nh3_ngrazing, SmallRuminants::Grazing);
n_solid_from_other	kg N /a	Annual N flux from other animals housing, solid fraction. Val(n_outhousing_solid, SmallRuminants::Housing);
tan_solid_from_other	kg N /a	Annual N flux as TAN from other animals housing, solid fraction. Val(tan_outhousing_solid, SmallRuminants::Housing);
tan_from_other	kg N /a	Annual N flux as TAN from other animals housing. Val(tan_outhousing, SmallRuminants::Housing);
n_excretion	kg N /a	Annual N excreted by other animals. Val(n_excretion, SmallRuminants::Excretion);
n_liquid_from_other	kg N /a	Annual N flux from other animals housing, liquid fraction. Val(n_outhousing_liquid, SmallRuminants::Housing);

82.5 Detailed process description

Summarizes the annual emission of NH3 for goats, fattening sheep and milksheep from housing, yard and grazing. Summarizes the annual N flux from housing to the storage for goats, fattening sheep and milksheep.

83 Livestock::SmallRuminants::Excretion

Agrammon Group – 13-11-09

83.1 Short description

Computes the annual N excretion of goats, fattening sheep and milksheep.

83.2 Input parameters

83.3 Technical parameters

83.4 Output

Parameter	Unit	Formula
n_sol_excretion	kg N /a	Annual soluble N excreted by a specified number of small ruminants. Out(share_Nsol) × Out(n_excretion);

standard_N_excretion	kg N /a	Annual standard N excretion for specified other animal category according to Flisch et al. (2009).
		
		my $key = "standard_N_excretion_" . In('animalcategory');
		return Tech($key);

animals	-	Number of small ruminants for the selected type in barn. In(animals);
n_excretion	kg N /a	Annual N excreted by a specified number of small ruminants. Out(standard_N_excretion) × In(animals);

share_Nsol	-	Nsol content of excreta of small ruminants. Derived from e.g. Peterson et al. (1998) or Burgos et al. (2005).
		
		my $key = "share_Nsol_" . In('animalcategory');
		return Tech($key);

83.5 Detailed process description

This process calculated the annual N excretion of small ruminats. The standard N excretion was taken from the official Swiss fertilizer guidelines. The Nsol content of the excreta is based on e.g. Peterson et al. (1998) or Burgos et al. (2005). These values were compiled on the basis of official feeding recommendations (Flisch et al. 2009) by H. Menzi.

83.5.1 References:

Burgos SA, Robinson PH, Fadel JG, DePeters EJ 2005. Ammonia volatilization potential: Prediction of urinary urea nitrogen output on lactating dairy cows. Agriculture, Ecosystems and Environment 111:261-269.

Peterson SO, Sommer SG, Aaes O, Soegaard K 1998. Ammonia losses from urine and dung of grazing cattle: effect of N intake. Atmospheric environment 32:295-300.

Flisch R, Sinaj S, Charles R, Richner W 2009. Grundlagen für die die Düngung im Acker- und Futterbau. Agrarforschung 16(2).

84 Livestock::SmallRuminants::Grazing

Agrammon Group – 13-11-09

84.1 Short description

Computes the annual NH3 emission from grazing goats, fattening sheep, and milksheep.

84.2 Input parameters

84.3 Technical parameters

84.4 Output

Parameter	Unit	Formula
grazing_days	d /a	Grazing days per year. In(grazing_days);
nh3_ngrazing	kg N /a	Annual NH3 emission from small ruminants from grazing. Out(n_sol_into_grazing) × Tech(er_small_ruminants_grazing);
n_into_grazing	kg N /a	Annual N excretion during grazing for small ruminants. Val(n_excretion, Excretion) × In(grazing_days) / 365 × In(grazing_hours) / 24;
n_remain_pasture	kg N /a	Annual N input on pastures. Out(n_into_grazing) - Out(nh3_ngrazing);
n_sol_into_grazing	kg N /a	Annual solable N (TAN) excretion during grazing for small ruminants. Val(n_sol_excretion, Excretion) × In(grazing_days) / 365 × In(grazing_hours) / 24;
grazing_hours	h /d	Grazing hours per day. In(grazing_hours);

84.5 Detailed process description

This process calculates the annual NH3 emission from grazing goats, fattening sheep and milksheep based on the total N excreted on the pastures. The N excreted is calculated according to the time the animals spend on the pasture. It assumes that the excretions on the pasture are proportional to the time the animals are grazed.

84.5.1 References:

Bussink DW 1992. Ammonia volatilization from grassland receiving nitrogen fertilizer and rotationally grazed by dairy cattle. Fertilizer Research 33:257-265.

Bussink DW 1994. Relationship between ammonia volatilization and nitrogen fertilizer application rate, intake and excretion of herbage nitrogen by cattle on grazed swards. Fertilizer Research 38:111-121.

Jarvis SC, Hatch DJ, Lockyer DR 1989. Ammonia fluxes from grazed grassland: annual losses from cattle production systems and their relation to nitrogen inputs. Journal of Agricultural Science 113:99-108.

Peterson SO, Sommer SG, Aaes O, Soegaard K 1998. Ammonia losses from urine and dung of grazing cattle: effect of N intake. Atmospheric environment 32:295-300.

Ross CA, Jarvis SC 2001. Measurement of emission and deposition pattern of ammonia from urine in grass swards. Atmospheric environment 35:867-875.

85 Livestock::SmallRuminants::Housing

Agrammon Group – 13-11-09

85.1 Short description

Computes the annual NH3 emission from small ruminant housing systems.

85.2 Input parameters

85.3 Technical parameters

85.4 Output

Parameter	Unit	Formula
tan_outhousing_liquid	kg N /a	Annual N flux as TAN out of housing, slurry or liquid fraction of N flux. 0
n_outhousing_liquid	kg N /a	Annual N flux out of housing, slurry or liquid fraction of N flux. 0
n_outhousing	kg N /a	Annual N flux out of the housing. Out(n_into_housing) - Out(nh3_nhousing);
n_into_housing	kg N /a	Annual N flux into the house. Val(n_excretion, Excretion) - Val(n_into_grazing, Grazing);
tan_outhousing	kg N /a	Annual N flux as TAN out of the housing. Out(n_sol_into_housing) - Out(nh3_nhousing);
nh3_nhousing	kg N /a	Annual NH3 emission from small ruminants housing systems per animal place. Val(n_excretion, Excretion) × Tech(er_housing) × Val(k_grazing, Housing::KGrazing)
n_sol_into_housing	kg N /a	Annual N flux as TAN into the house. Val(n_sol_excretion, Excretion) - Val(n_sol_into_grazing, Grazing);
tan_outhousing_solid	kg N /a	Annual N flux as TAN out of housing, manure fraction of N flux. Out(tan_outhousing);
n_outhousing_solid	kg N /a	Annual N flux out of housing, manure fraction of N flux. Out(n_outhousing);

85.5 Detailed process description

This process calculates the NH3 emission in small ruminants housing depending on the N excretion and the housing systems. The NH3 emission is assumed to be proportional to the total N excretion of the animals because the contaminated surfaces will primarily drive emissions, which will remain active even when animals are on the pasture or exercise yard.

A proportional correction is applied according to the area per animal.

A correction is applied if the part of the day grazing is above a defined grazing hours per days.

85.5.1 Definition of System boundaries for the housing Process:

For housing systems with integrated exercise yards, it is difficult to distinguish between emissions from housing, exercise yard and storage. For these housingtypes the emission may be only validated for the sum of housing, exercise yard and storage emission.

86 Livestock::SmallRuminants::Housing::KGrazing

Agrammon Group – 13-11-09

86.1 Short description

Computes the correction factor for the reduction of small ruminant housing emission if the number of grazing hours per day does increase a specific limit.

86.2 Input parameters

86.3 Technical parameters

86.4 Output

Parameter	Unit	Formula

k_grazing	-	The correction factor for the reduction of the housing emission depending on the number of grazing hours per day and the grazing days per year.
		
		if (Val('grazing_hours', '..::Grazing') < 5){
		return ((365.0-Val('grazing_days', '..::Grazing')) + ((1-Tech(k_grazing_reduction_lw5h))×Val('grazing_days', '..::Grazing'))) / 365.0 ;
		}
		elsif (Val('grazing_hours', '..::Grazing') < 12.0){
		return ((365.0-Val('grazing_days', '..::Grazing')) + ((1-Tech(k_grazing_reduction_lw12h))×Val('grazing_days', '..::Grazing'))) / 365.0 ;
		}
		elsif (Val('grazing_hours', '..::Grazing') < 22.0) {
		return ((365.0-Val('grazing_days', '..::Grazing')) + ((1-Tech(k_grazing_reduction_lw22h))×Val('grazing_days', '..::Grazing'))) / 365.0 ;
		}
		elsif (Val('grazing_hours', '..::Grazing') ≥ 22.0) {
		return ((365.0-Val('grazing_days', '..::Grazing')) + ((1-Tech(k_grazing_reduction_gt22h))×Val('grazing_days', '..::Grazing'))) / 365.0 ;
		}
		else {
		return 1; # no correction
		};

86.5 Detailed process description

This process calculates the correction factor for the non proportional change of the housing emission according to the grazing hours per day (Webb et al. 2005). It is based on an empirical estimation of Menzi and Katz (1997). The concept has been lately supported by measurements in the UK (Defra 2002), where reductions comparable to those assumed by Menzi and Katz (1997) were reported.

86.5.1 References:

Department for Environment, Food & Rural Affairs, Defra 2002. Ammonia in the UK. DEFRA Publications, London. Menzi H, Katz PE 1997. A differentiated approach to calculate ammonia emissions from animal husbandry. In: Voermans JAM and Monteny GJ (Eds): "Ammonia and odour emissions from animal production facilities", Proc. International Symposium, Vinkeloord, NL, 6-10 October 1997, 35-42. Webb J, Misselbrook TH 2005. A mass-flow model of ammonia emissions from UK livestock production. Atmospheric environment 38: 2163-2176.

87 PlantProduction

Agrammon Group – 13-11-09

87.1 Short description

Computes the annual NH3 emission from plant production.

87.2 Input parameters

87.3 Technical parameters

87.4 Output

Parameter	Unit	Formula
solid_digestate	t /a	Amount of Solid digestate in t /a. Val(solid_digestate, PlantProduction::RecyclingFertiliser);
liquid_digestate	m3 /a	Amount of liquid digestate in m3 /a. Val(liquid_digestate, PlantProduction::RecyclingFertiliser);
mineral_nitrogen_fertiliser-_except_urea	kg N /a	Amount of nitrogen fertiliser (except urea) in kg N /a. Val(mineral_nitrogen_fertiliser_except_urea, PlantProduction::MineralFertiliser);
agricultural_area	ha	Agricultural area (ha). Val(agricultural_area, PlantProduction::AgriculturalArea);
compost	t /a	Amount of compost in t /a. Val(compost, PlantProduction::RecyclingFertiliser);
mineral_nitrogen_fertiliser-_urea	kg N /a	Amount of urea in kg N /a. Val(mineral_nitrogen_fertiliser_urea, PlantProduction::MineralFertiliser);
nh3_nplantproduction	kg N /a	Annual NH3 emission from plant production. Val(nh3_nagriculturalarea, PlantProduction::AgriculturalArea) + Val(nh3_nmineralfertiliser, PlantProduction::MineralFertiliser) + Val(nh3_nrecyclingfertiliser, PlantProduction::RecyclingFertiliser)

87.5 Detailed process description

This process summarizes the contribution of the plant production to the total NH3 emission.

87.5.1 Differences to DYNAMO

88 PlantProduction::AgriculturalArea

Agrammon Group – 13-11-09

88.1 Short description

Computes the annual NH3 emission from agricultural area application.
Attention: simplified model based on total N output from storage!!!

88.2 Input parameters

Parameter	Unit	Description
agricultural_area	ha	Agricultural area.

88.3 Technical parameters

Parameter	Value	Unit	Description
er_agricultural_area	2	kg N /ha /a	Emission rate from the agricultural area. The average rate has been derived from Schjoerring and Mattson (2001). Emission based on kg/ ha AA (AA = agricultural area, Landwirschaftliche Nutzfläche). N ist NH3 N.

88.4 Output

Parameter	Unit	Formula
agricultural_area	ha	Agricultural area (ha). In(agricultural_area);
nh3_nagriculturalarea	kg N /a	NH3 emission from agricultural area. In(agricultural_area) × Tech(er_agricultural_area);

88.5 Detailed process description

This process computes the annual average NH3 emission from agricultural area application. The standard emission factor is corrected according to the TAN content and the application rate, the application technology, the crops to which the manure is applied, respected soft measures during application and the application season, the time lag between application and incorporation, the incorporation technology used, and the proportion of solid manure that is applied on hot days.

88.5.1 References:

Vanderweerden and Jarvis (1997)

89 PlantProduction::MineralFertiliser

Agrammon Group – 13-11-09

89.1 Short description

Computes the annual NH3 emission from mineral fertiliser application.

Attention: simplified model based on total N output from storage!!!

89.2 Input parameters

Parameter	Unit	Description
mineral_nitrogen_fertiliser-_urea	kg N /a	Amount of urea in kg N /a.
mineral_nitrogen_fertiliser-_except_urea	kg N /a	Amount of nitrogen fertiliser (except urea) in kg N /a.

89.3 Technical parameters

Parameter	Value	Unit	Description
er_App_mineral_nitrogen-_fertiliser_urea	0.15	-	Emission rate for the application of urea. The average rate has been derived from Vanderweerden and Jarvis (1997). Emission based on Ntot.
er_App_mineral_nitrogen-_fertiliser_except_urea	0.02	-	Emission rate for the application of ammonium nitrate. The average rate has been derived from Vanderweerden and Jarvis (1997). Emission based on Ntot.

89.4 Output

Parameter	Unit	Formula
mineral_nitrogen_fertiliser-_except_urea	kg N /a	Amount of nitrogen fertiliser (except urea) in kg N /a. In(mineral_nitrogen_fertiliser_except_urea);
nh3_nmineralfertiliser	kg N /a	NH3 emission from mineral fertiliser application. In(mineral_nitrogen_fertiliser_urea) × Tech(er_App_mineral_nitrogen_fertiliser_urea) + In(mineral_nitrogen_fertiliser_except_urea) × Tech(er_App_mineral_nitrogen_fertiliser_except_urea);
mineral_nitrogen_fertiliser-_urea	kg N /a	Amount of urea in kg N /a. In(mineral_nitrogen_fertiliser_urea);

89.5 Detailed process description

This process computes the annual average NH3 emission from mineral fertiliser application. The standard emission factor is corrected according to the TAN content and the application rate, the application technology, the crops to which the manure is applied, respected soft measures during application and the application season, the time lag between application and incorporation, the incorporation technology used, and the proportion of solid manure that is applied on hot days.

89.5.1 References:

Vanderweerden and Jarvis (1997)

90 PlantProduction::RecyclingFertiliser

Agrammon Group – 13-11-09

90.1 Short description

Computes the annual NH3 emission from recycling fertiliser application.

Attention: simplified model based on total N output from storage!!!

90.2 Input parameters

Parameter	Unit	Description
compost	t /a	Amount of compost (in t fresh matter per year). Kompost besteht aus Grünabfällen nicht-landwirtschafltlicher Herkunft von gewerblich-industriellen Anlagen oder von Feldrandkompostierung.
solid_digestate	t /a	Amount of solid digestate form industrial factories.
liquid_digestate	m3 /a	Amount of liquid digestate form industrial factories.

90.3 Technical parameters

Parameter	Value	Unit	Description
er_compost 0.3 kg TAN per t fresh matter (Flisch et al., 2009). of TAN.	0.24	kg N / t	Emission rate from compost, calculated with an emission rate of 80
er_solid_digestate	0.24	kg N / t	Emission rate for solid digestat from industrial plantse, calculated with an emmission rate of 80
er_liquid_digestate	1.2	kg N / t	Emission rate from liquid digestate from industrial plants, calculated with an emmission rate of 60

90.4 Output

Parameter	Unit	Formula
solid_digestate	t /a	Amount of Solid digestate in t /a. In(solid_digestate);
liquid_digestate	m3 /a	Amount of liquid digestate in m3 /a. In(liquid_digestate);
nh3_ncompost	kg N /a	NH3 emission from compost. In(compost) × Tech(er_compost);
compost	t /a	Amount of compost in t /a. In(compost);
nh3_nrecyclingfertiliser	kg N /a	NH3 emission from total recycling fertiliser. In(liquid_digestate) × Tech(er_liquid_digestate) + In(solid_digestate) × Tech(er_solid_digestate) + In(compost) × Tech(er_compost);
nh3_nliquid_degestate	kg N /a	NH3 emission from liquid digestate. In(liquid_digestate) × Tech(er_liquid_digestate);
nh3_nsolid_degestate	kg N /a	NH3 emission from solid digestate. In(solid_digestate) × Tech(er_solid_digestate);

90.5 Detailed process description

This process computes the annual average NH3 emission from recycling fertiliser application. The standard emission factor is corrected according to the TAN content and the application rate, the application technology, the crops to which the manure is applied, respected soft measures during application and the application season, the time lag between application and incorporation, the incorporation technology used, and the proportion of solid manure that is applied on hot days.

90.5.1 References:

Vanderweerden and Jarvis (1997)

91 SharesByAnimalCategory

Agrammon Group – 13-11-09

91.1 Short description

Collects the annual NH3 emission by Animalcategories, and calulates its share of the total

91.2 Input parameters

91.3 Technical parameters

91.4 Output

Parameter	Unit	Formula
share_nh3_poultry_housing_and_yard	%	Annual NH3 emission from poultry from all housings and yards. if(Val('nh3_ntotal',Total) >0){ Val(nh3_npoultry_housing_and_yard,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_equides_application	%	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_nequides_application,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_otherpig_storage	%	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_notherpig_storage,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_fatteningpig_application	%	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_nfatteningpig_application,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_recyclingfertiliser	%	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_nrecyclingfertiliser,PlantProduction::RecyclingFertiliser)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_fatteningpig_grazing	%	Annual NH3 emission from fattening pigs grazing areas. if(Val('nh3_ntotal',Total) >0){ Val(nh3_nfatteningpig_grazing,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_fatteningpig_housing_and_yard	%	Annual NH3 emission from fattening pigs from all housings and yards. if(Val('nh3_ntotal',Total) >0){ Val(nh3_nfatteningpig_housing_and_yard,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_dairycow_grazing	%	Annual NH3 emission from dairy cows grazing areas. if(Val('nh3_ntotal',Total) >0){ Val(nh3_ndairycow_grazing,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total) ; }else{0;}

share_nh3_livestock	%	Annual NH3 emission (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_nanimalproduction,Total)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_other-_application	%	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_nother_application,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_poultry_storage	%	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_npoultry_storage,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_cattle_storage	%	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_ncattle_storage,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_agriculturalarea	%	Annual NH3 emission from small ruminants from all housings and yards. if(Val('nh3_ntotal',Total) >0){ Val(nh3_nagriculturalarea,PlantProduction::AgriculturalArea)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_dairycow-_housing_and_yard	%	Annual NH3 emission from dairy cows from all housings and yards. if(Val('nh3_ntotal',Total) >0){ Val(nh3_ndairycow_housing_and_yard,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_dairycow-_storage	-	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_ndairycow_storage,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_othercattle-_grazing	%	Annual NH3 emission from other cattle grazing areas. if(Val('nh3_ntotal',Total) >0){ Val(nh3_nothercattle_grazing,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_poultry_grazing	%	Annual NH3 emission from poultry grazing areas. if(Val('nh3_ntotal',Total) >0){ Val(nh3_npoultry_grazing,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_small_ruminant-_storage	%	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_nsmall_ruminant_storage,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}

share_nh3_othercattle-_housing_and_yard	%	Annual NH3 emission from cattle from all housings and yards. if(Val('nh3_ntotal',Total) >0){ Val(nh3_nothercattle_housing_and_yard,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_livestock_storage	%	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_nstorage,Storage)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_poultry-_application	%	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_npoultry_application,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_fatteningpig-_storage	%	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_nfatteningpig_storage,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_otherpig-_housing_and_yard	%	Annual NH3 emission from other pigs form all housings and yards. if(Val('nh3_ntotal',Total) >0){ Val(nh3_notherpig_housing_and_yard,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_pig_storage	%	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_npig_storage,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_pig_housing-_and_yard	%	Annual NH3 emission from all pigs from all housings and yards. if(Val('nh3_ntotal',Total) >0){ Val(nh3_npig_housing_and_yard,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_othercattle-_application	%	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_nothercattle_application,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_cattle-_application	%	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_ncattle_application,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_pig_application	%	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_npig_application,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}

share_nh3_total	%	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) 100;
share_nh3_equides_housing_and_yard	%	Annual NH3 emission from equides from all housings and yards. if(Val('nh3_ntotal',Total) >0){ Val(nh3_nequides_housing_and_yard,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_othercattle_storage	%	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_nothercattle_storage,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_small_ruminant_application	%	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_nsmall_ruminant_application,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_equides_storage	%	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_nequides_storage,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_otherpig_grazing	%	Annual NH3 emission from other pigs grazing areas. if(Val('nh3_ntotal',Total) >0){ Val(nh3_notherpig_grazing,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_other_housing_and_yard	%	Annual NH3 emission from equides and small ruminants from all housings and yards. if(Val('nh3_ntotal',Total) >0){ Val(nh3_nother_housing_and_yard,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_other_grazing	%	Annual NH3 emission from equides and small ruminants grazing areas. if(Val('nh3_ntotal',Total) >0){ Val(nh3_nother_grazing,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_cattle_housing_and_yard	%	Annual NH3 emission from cattle from all housings and yards. if(Val('nh3_ntotal',Total) >0){ Val(nh3_ncattle_housing_and_yard,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_cattle_grazing	%	Annual NH3 emission from cattle grazing areas. if(Val('nh3_ntotal',Total) >0){ Val(nh3_ncattle_grazing,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_livestock_housing_and_yard	%	Annual NH3 emission from small ruminants from all housings and yards. if(Val('nh3_ntotal',Total) >0){ Val(nh3_nhousing_and_yard,Livestock)×100 / Val('nh3_ntotal',Total); }else{0;}

share_nh3_pig_grazing	%	Annual NH3 emission from all pigs grazing areas. if(Val('nh3_ntotal',Total) >0){ Val(nh3_npig_grazing,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_plant-_production	%	Annual NH3 emission from livestock grazing areas. if(Val('nh3_ntotal',Total) >0){ Val(nh3_nplantproduction,PlantProduction)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_livestock-_application	%	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_napplication,Application)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_dairycow-_application	%	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_ndairycow_application,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_equides_grazing	%	Annual NH3 emission from equides grazing areas. if(Val('nh3_ntotal',Total) >0){ Val(nh3_nequides_grazing,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_livestock_grazing	%	Annual NH3 emission from livestock grazing areas. if(Val('nh3_ntotal',Total) >0){ Val(nh3_ngrazing,Livestock)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_small_ruminant-_housing_and_yard	%	Annual NH3 emission from small ruminants from all housings and yards. if(Val('nh3_ntotal',Total) >0){ Val(nh3_nsmall_ruminant_housing_and_yard,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_small_ruminant-_grazing	%	Annual NH3 emission from small ruminants grazing areas. if(Val('nh3_ntotal',Total) >0){ Val(nh3_nsmall_ruminant_grazing,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_other_storage	%	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_nother_storage,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_mineralfertiliser	%	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_nmineralfertiliser,PlantProduction::MineralFertiliser)×100 / Val('nh3_ntotal',Total); }else{0;}
share_nh3_otherpig-_application	%	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) if(Val('nh3_ntotal',Total) >0){ Val(nh3_notherpig_application,SummaryByAnimalCategory)×100 / Val('nh3_ntotal',Total); }else{0;}

91.5 Detailed process description

92 Storage

Agrammon Group – 13-11-09

92.1 Short description

Computes the annual NH3 emission from manure storage based on a categorised slurry type and the cover type.

92.2 Input parameters

92.3 Technical parameters

Parameter	Value	Unit	Description
mineralizationrate_liquid	0.1	-	A netto mineralization of 10% from Norg to NSol/TAN is assuemd, according to the GAS_EM Model

92.4 Output

Parameter	Unit	Formula
nh3_nstorage	kg N /a	Annual NH3 emission from storage. Sum(nh3_nliquid, Storage::Slurry) + Val(nh3_nsolid, Storage::SolidManure);

mineralization_liquid	kg N /a	Annual TAN mineralized from not TAN fraction in liquid storage.
		
		if(Val(tan_into_storage_liquid, Livestock) < Sum(nh3_nliquid, Storage::Slurry))
		{0}
		else
		{
		Tech(mineralizationrate_liquid) ×
		(Val(n_into_storage_liquid, Livestock) - Val(tan_into_storage_liquid, Livestock))
		}

tan_into_application	kg TAN /a	Annual TAN flux out of storage for application. Out(tan_into_application_liquid) + Out(tan_into_application_manure) ;
nh3_nstorage_liquid	kg N /a	Annual NH3 emission from storage. Sum(nh3_nliquid, Storage::Slurry);
n_into_application	kg N /a	Annual N flux out of storage for application. Out(n_into_application_liquid) + Out(n_into_application_manure) ;
n_into_application_manure	kg N /a	Annual N flux out of storage for manure application. Val(n_into_storage_solid, Livestock) - Val(nh3_nsolid, Storage::SolidManure);

n_into_application_liquid	kg N /a	Annual N flux out of storage for application.
		
		if(Val(n_into_storage_liquid, Livestock) < Sum(nh3_nliquid, Storage::Slurry))
		{0}
		else
		{Val(n_into_storage_liquid, Livestock) - Sum(nh3_nliquid, Storage::Slurry)};

nh3_nstorage_solid	kg N /a	Annual NH3 emission from storage. Val(nh3_nsolid, Storage::SolidManure);
tan_into_application_manure	kg TAN /a	Annual TAN flux out of storage for manure application. Val(tan_into_storage_solid, Livestock) - Val(nh3_nsolid, Storage::SolidManure);

tan_into_application_liquid	kg N /a	Annual N flux as TAN out of storage for application.
		if(Val(tan_into_storage_liquid, Livestock) < Sum(nh3_nliquid, Storage::Slurry))
		{0}
		else
		{Val(tan_into_storage_liquid, Livestock) - Sum(nh3_nliquid, Storage::Slurry) +
		Out(mineralization_liquid)};

92.5 Detailed process description

This process calculates the NH3 emission from slurry storage, considering both slurry from slurry based systems and liquid from liquid/solid systems. The surface to volume ration (measure for the emitting surface), the cover type and artificial slurry aeration are accounted for via correction factors. Calculations are performed independently for slurry and liquid from liquid/solid systems with the same procedure.

92.5.1 References:

De Bode MJC, 1990. Vergleich der Ammoniakemissionen aus verschiedenen Flüssigmistlagersystemen. In: Ammoniak in der Umwelt. Hrsg.: KTBL und VDI, Münster, 34:1-13.

93 Storage::Slurry

Agrammon Group – 13-11-09

93.1 Short description

Describes a single liquid manuare storage.

93.2 Input parameters

93.3 Technical parameters

93.4 Output

Parameter	Unit	Formula

c_mixing	-	Correction factor for number of mixing frequency in storage, accoording to selected levels.
		
		my $key = "c_mixing_" . In(mixing_frequency);
		return Tech($key);

nh3_nliquid	kg N /a	Annual NH3 emission from slurry storage. Val(ef_liquid, Slurry::EFLiquid) × Out(surface_area) × Out(c_mixing);

surface_area	m2	Surface area of slurry storage.
		
		if(In('depth') ≤ 0){
		return 0;
		}else{
		return In('volume') / In('depth');
		}

93.5 Detailed process description

This Process calculates the annual NH3 emission from a single liquid manuare storage, considering a specific emission factor.

93.5.1 References

De Bode MJC, 1990. Vergleich der Ammoniakemissionen aus verschiedenen Flüssigmistlagersystemen. In: Ammoniak in der Umwelt. Hrsg.: KTBL und VDI, Münster, 34:1-13. Menzi H, Frick R, Kaufmann R, 1997a. Ammoniak-Emissionen in der Schweiz: Ausmass und technische Beurteilung des Reduktionspotentials. Eidgenössische Forschungsanstalt für Agrarökologie und Landbau, Zürich-Reckenholz. 107pp. Sommer SG, Christensen BT, Nielsen NE, Schjorring JK, 1993. Ammonia volatilization during storage of cattle and pig slurry - effect of surface cover. Journal of Agricultural Science 121:63-71.

94 Storage::Slurry::EFLiquid

Agrammon Group – 13-11-09

94.1 Short description

Calculates the emission factor for a specific slurry storage.

94.2 Input parameters

94.3 Technical parameters

94.4 Output

Parameter	Unit	Formula

ef_pigs_liquid	kg N /m2 /a	Emission factor of a specific liquid storage for pig.
		
		my $key = "ef_pig_" . In(cover_type);
		return Tech($key);

ef_liquid	kg N /m2 /a	Emission factor of a specific liquid storage, if storage conatains cattle and pig manure, a maen distribution depending on the n flow into liqud storage is assumed. Which does not consider possible separet storage units.
		
		if(In(contains_cattle_manure) eq 'yes' and In(contains_pig_manure) eq 'no'){
		return Out(ef_cattle_liquid);
		}
		elsif(In(contains_cattle_manure) eq 'no' and In(contains_pig_manure) eq 'yes'){
		return Out(ef_pigs_liquid);
		}
		elsif(In(contains_cattle_manure) eq 'yes' and In(contains_pig_manure) eq 'yes'){
		if(Val(n_into_storage_liquid, ::Livestock) != 0){
		return (Val(n_into_storage_liquid_pigs, ::Livestock) × Out(ef_pigs_liquid) +
		(Val(n_into_storage_liquid, ::Livestock) -
		Val(n_into_storage_liquid_pigs, ::Livestock)) × Out(ef_cattle_liquid))
		/ Val(n_into_storage_liquid, ::Livestock)
		}else{
		return (Out(ef_cattle_liquid) + Out(ef_pigs_liquid))/2;
		}
		}
		else{
		ERR "Invalid values in \"contains_cattel_manure\" and/or \"contains_cattel_manure\"\n";
		if(Val(n_into_storage_liquid, ::Livestock) != 0){
		return (Val(n_into_storage_liquid_pigs, ::Livestock) × Out(ef_pigs_liquid) +
		(Val(n_into_storage_liquid, ::Livestock) -
		Val(n_into_storage_liquid_pigs, ::Livestock)) × Out(ef_cattle_liquid))
		/ Val(n_into_storage_liquid, ::Livestock)
		}else{
		return (Out(ef_cattle_liquid) + Out(ef_pigs_liquid))/2;
		}
		};

ef_cattle_liquid	kg N /m2 /a	Emission factor of a specific liquid storage for cattle.
		
		my $key = "ef_cattle_" . In(cover_type);
		return Tech($key);

94.5 Detailed process description

94.5.1 References:

UNECE 2007. Guidance document on control techniques for preventing and abating emissions of ammonia. ECE/EB.AIR/WG.5/2007/13.

De Bode MJC, 1990. Vergleich der Ammoniakemissionen aus verschiedenen Flüssigmistlagersystemen. In: Ammoniak in der Umwelt. Hrsg.: KTBL und VDI, Münster(D), 34:1-13.

Sommer SG, Christensen BT, Nielsen NE, Schjorring JK, 1993. Ammonia volatilization during storage of cattle and pig slurry - effect of surface cover. Journal of Agricultural Science 121:63-71.

95 Storage::SolidManure

Agrammon Group – 13-11-09

95.1 Short description

Computes the annual NH3 emission from solid manure storages.

95.2 Input parameters

95.3 Technical parameters

95.4 Output

Parameter	Unit	Formula
n_fromsolid	kg N /a	Annual N flux from solid storage to application. Val(n_into_storage_solid, ::Livestock) - Out(nh3_nsolid);
nh3_nsolid	kg N /a	Annual NH3 emission from storage of solid manure. Val(nh3_nsolid_dairycows_cattle, SolidManure::Solid) + Val(nh3_nsolid_pigs, SolidManure::Solid) + Val(nh3_nsolid_horses_otherequides_smallruminants, SolidManure::Solid) + Val(nh3_npoultry, SolidManure::Poultry);

95.5 Detailed process description

This process calculates the annual NH3 emission from solid manure storage, considering a mean emission rate on TAN flux in solid storage.

96 Storage::SolidManure::Poultry

Agrammon Group – 13-11-09

96.1 Short description

Computes the annual NH3 emission from poultry manure storages.

96.2 Input parameters

Parameter	Unit	Description
share_applied_direct-_poultry_manure	%	Share of poultry manure applied to land without storage.
share_covered_basin	%	Share of droppings or mist from poultry stored in covered basin.

96.3 Technical parameters

Parameter	Value	Unit	Description
er_layers_growers_other-_poultry	0.25	-	Emission rate for layers, growers and other poultry for manure (deep pit, deep litter) and droppings (manure belt)(based on EAGER workshop, January 2008: 15% Ntot, converted using Nsol 60% and emission factor of 25%.
er_turkeys_broilers	0.1	-	Emission rate for manure of broilers and turkeys based on EAGER workshop, January 2008: 6% Ntot, converted using Nsol 60% and emission factor of 10%.
c_droppings_mist_covered-_basin	0.6	-	Reduction of emission rate for the droppings or mist stored in covered basin for poultry.
immobilizationrate_poultry	0.4	-	A netto immobilization of 40% from NSol/TAN to Norg is assuemd, according to the GAS_EM Model

96.4 Output

Parameter	Unit	Formula
n_into_application	kg N /a	Annual N flux out of storage for manure application. Val(n_into_storage_poultry, ::Livestock) - Out(nh3_npoultry);

c_covered_basin	-	Correction factor for storage droppings or mist in coverd basin.
		
		if(In(share_covered_basin) $\geq$ 0 && In(share_covered_basin) $\leq$100){
		1 - (Tech('c_droppings_mist_covered_basin') $\times$ In(share_covered_basin)/100);
		}else {
		ERR "Invalid 'share_covered_basin' defined!";
		return 1.0;
		}

immobilization_poultry-_turkeys_broilers	kg N /a	Annual TAN immobilized from TAN fraction in poultry manure storage. Tech(immobilizationrate_poultry) $\times$ (Val(tan_into_storage_poultry_turkeys_broilers, ::Livestock) - Out(nh3_npoultry_turkeys_broilers))
immobilization_poultry-_layers_growers_other-_poultry	kg N /a	Annual TAN immobilized from TAN fraction in poultry manure storage. Tech(immobilizationrate_poultry) $\times$ (Val(tan_into_storage_poultry_layers_growers_other_poultry, ::Livestock) - Out(nh3_npoultry_layers_growers_other_poultry))

nh3_npoultry_turkeys-_broilers	kg N /a	Annual NH3 emission from poultry manure storage.
		
		if (In(share_applied_direct_poultry_manure) $\geq$ 0 && In(share_applied_direct_poultry_manure) $\leq$ 100) {
		return (Tech(er_turkeys_broilers) $\times$ Val(tan_into_storage_poultry_turkeys_broilers, ::Livestock) $\times$ (1-(In(share_applied_direct_poultry_manure)/100))$\times$ Out(c_covered_basin));
		} else {
		ERR "Invalid 'share_applied_direct_poultry_manure' defined!";
		};

n_into_application_turkeys-_broilers	kg N /a	Annual N flux out of storage for manure application. Val(n_into_storage_poultry_turkeys_broilers, ::Livestock) - Out(nh3_npoultry_turkeys_broilers);
tan_into_application	kg N /a	Annual N flux as TAN out of storage for manure application. Val(tan_into_storage_poultry, ::Livestock) - Out(nh3_npoultry) - Out(immobilization_poultry);
tan_into_application-_turkeys_broilers	kg N /a	Annual N flux as TAN out of storage for manure application. Val(tan_into_storage_poultry_turkeys_broilers, ::Livestock) - Out(nh3_npoultry_turkeys_broilers) - Out(immobilization_poultry_turkeys_broilers);
tan_into_application_layers-_growers_other_poultry	kg N /a	Annual N flux as TAN out of storage for manure application. Val(tan_into_storage_poultry_layers_growers_other_poultry, ::Livestock) - Out(nh3_npoultry_layers_growers_other_poultry) - Out(immobilization_poultry_layers_growers_other_poultry);

nh3_npoultry_layers-_growers_other_poultry	kg N /a	Annual NH3 emission from poultry manure storage.
		
		if (In(share_applied_direct_poultry_manure) $\geq$ 0 && In(share_applied_direct_poultry_manure) $\leq$ 100) {
		(Tech(er_layers_growers_other_poultry) $\times$ Val(tan_into_storage_poultry_layers_growers_other_poultry, ::Livestock) $\times$ (1-(In(share_applied_direct_poultry_manure)/100)) $\times$ Out(c_covered_basin));
		} else {
		ERR "Invalid 'share_applied_direct_poultry_manure' defined!";
		return 0;
		};

nh3_npoultry	kg N /a	Annual NH3 emission from poultry manure storage. Out(nh3_npoultry_layers_growers_other_poultry) + Out(nh3_npoultry_turkeys_broilers);
immobilization_poultry	kg N /a	Annual TAN immobilized from TAN fraction in poultry manure storage. Tech(immobilizationrate_poultry) $\times$ (Val(tan_into_storage_poultry, ::Livestock) - Out(nh3_npoultry))
n_into_application_layers-_growers_other_poultry	kg N /a	Annual N flux out of storage for manure application. Val(n_into_storage_poultry_layers_growers_other_poultry, ::Livestock) - Out(nh3_npoultry_layers_growers_other_poultry);

96.5 Detailed process description

This process calculates the annual NH3 emission from poultry manure storage, considering a mean emission rate on TAN flux in storage.

96.5.1 References:

European Agricultural Gaseous Emissions Inventory Researchers Network - EAGER workshop, January 2008.

97 Storage::SolidManure::Solid

Agrammon Group – 13-11-09

97.1 Short description

Computes the annual NH3 emission from solid manure storages.

97.2 Input parameters

Parameter	Unit	Description
share_applied_direct_cattle-_other_manure	%	Share of cattle manure applied to land without storage.
share_applied_direct_pig-_manure	%	Share of pig manure applied to land without storage.

97.3 Technical parameters

Parameter	Value	Unit	Description
er_tan_pigs	0.5	-	The value has been derived from the Eager workshop, January 2008: (additional explanation following)
er_tan_cattle_other	0.3	-	The value has been derived from the Eager workshop, January 2008: (additional explanation following)
immobilizationrate_solid	0.4	-	A netto immobilization of 40% from NSol/TAN to Norg is assuemd, according to the GAS_EM Model

97.4 Output

Parameter	Unit	Formula
n_into_application-_horses_otherequides-_smallruminants	kg N /a	Annual N flux out of storage for manure application. Val(n_into_storage_solid_horses_otherequides_smallruminants, ::Livestock) - Out(nh3_nsolid_horses_otherequides_smallruminants);
immobilization	kg N /a	Annual TAN immobilized from TAN fraction in solid manure storage. Out(immobilization_pigs) + Out(immobilization_dairycows_cattle) + Out(immobilization_horses_otherequides_smallruminants);
nh3_nsolid_horses-_otherequides-_smallruminants	kg N /a	Annual NH3 emission from solid storage. Tech(er_tan_cattle_other) × Out(tan_into_storage_horses_otherequides_smallruminants);

tan_into_storage-_horses_otherequides-_smallruminants	kg N /a	Annual NH3 emission from solid storage.
		
		if (In(share_applied_direct_cattle_other_manure) > 1) {
		return (Val(tan_into_storage_solid_horses_otherequides_smallruminants, ::Livestock) × (1- (In(share_applied_direct_cattle_other_manure)/100)))
		} else {
		return (Val(tan_into_storage_solid_horses_otherequides_smallruminants, ::Livestock) × (1-(In(share_applied_direct_cattle_other_manure))))
		};

nh3_nsolid_dairycows-_cattle	kg N /a	Annual NH3 emission from solid storage. Tech(er_tan_cattle_other) × Out(tan_into_storage_dairycows_cattle)
immobilization_dairycows-_cattle	kg N /a	Annual TAN immobilized from TAN fraction in solid manure storage. Tech(immobilizationrate_solid) × (Out(tan_into_storage_dairycows_cattle) - Out(nh3_nsolid_dairycows_cattle))

tan_into_storage_pigs	kg N /a	Annual NH3 emission from solid storage.
		
		if (In(share_applied_direct_pig_manure) > 1) {
		return ((Val(tan_into_storage_solid_pigs, ::Livestock)) × (1-(In(share_applied_direct_pig_manure)/100)))
		} else {
		return ((Val(tan_into_storage_solid_pigs, ::Livestock)) × (1-In(share_applied_direct_pig_manure)))
		};

tan_into_application-_dairycows_cattle_pigs	kg N /a	Annual N flux out of storage for manure application. Val(tan_into_storage_solid_dairycows_cattle, ::Livestock) + Val(tan_into_storage_solid_pigs, ::Livestock) - Out(nh3_nsolid_dairycows_cattle) - Out(nh3_nsolid_pigs) - Out(immobilization_dairycows_cattle) - Out(immobilization_pigs);
nh3_nsolid_pigs	kg N /a	Annual NH3 emission from solid storage. Tech(er_tan_pigs) × Out(tan_into_storage_pigs);

tan_into_storage-_dairycows_cattle	kg N /a	Annual NH3 emission from solid storage.
		
		if (In(share_applied_direct_cattle_other_manure) > 1) {
		return (Val(tan_into_storage_solid_dairycows_cattle, ::Livestock) × (1-(In(share_applied_direct_cattle_other_manure)/100)))
		} else {
		return (Val(tan_into_storage_solid_dairycows_cattle, ::Livestock) × (1-In(share_applied_direct_cattle_other_manure)))
		};

tan_into_application	kg N /a	Annual N flux as TAN out of storage for manure application. Val(tan_into_storage_solid, ::Livestock) - Out(nh3_nsolid) - Out(immobilization);
n_into_application_manure	kg N /a	Annual N flux out of storage for manure application. Val(n_into_storage_solid, ::Livestock) - Out(nh3_nsolid);
nh3_nsolid	kg N /a	Annual NH3 emission from solid storage. Tech(er_tan_cattle_other) × Out(tan_into_storage_dairycows_cattle) + Tech(er_tan_pigs) × Out(tan_into_storage_pigs) + Tech(er_tan_cattle_other) × Out(tan_into_storage_horses_otherequides_smallruminants);
immobilization-_horses_otherequides-_smallruminants	kg N /a	Annual TAN immobilized from TAN fraction in solid manure storage. Tech(immobilizationrate_solid) × (Out(tan_into_storage_horses_otherequides_smallruminants) - Out(nh3_nsolid_horses_otherequides_smallruminants))
immobilization_pigs	kg N /a	Annual TAN immobilized from TAN fraction in solid manure storage. Tech(immobilizationrate_solid) × (Out(tan_into_storage_pigs) - Out(nh3_nsolid_pigs))
n_into_application-_dairycows_cattle_pigs	kg N /a	Annual N flux out of storage for manure application. Val(n_into_storage_solid_dairycows_cattle_pigs, ::Livestock) - Out(nh3_nsolid_dairycows_cattle) - Out(nh3_nsolid_pigs);
tan_into_application-_horses_otherequides-_smallruminants	kg N /a	Annual N flux out of storage for manure application. Out(tan_into_storage_horses_otherequides_smallruminants) - Out(nh3_nsolid_horses_otherequides_smallruminants) - Out(immobilization_horses_otherequides_smallruminants);

97.5 Detailed process description

This process calculates the annual NH3 emission from solid manure storage, considering a mean emission rate on TAN flux in solid storage.

98 SummaryByAnimalCategory

Agrammon Group – 13-11-09

98.1 Short description

Collects the annual NH3 emission by Animalcategories

98.2 Input parameters

98.3 Technical parameters

98.4 Output

Parameter	Unit	Formula
nh3_npig_storage_solid	kg N /a	Annual NH3 emission from storage solid(estimation proportional to input of animalcategory in storage) Out(share_storage_solid_pig) × Val(nh3_nstorage_solid, Storage);
nh3_nfatteningpig_storage	kg N /a	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) Out(nh3_nfatteningpig_storage_solid) + Out(nh3_nfatteningpig_storage_liquid);
nh3_ndairycow_total	kg N /a	Annual NH3 emission from dairycow (Application and storage, estimation proportional to input of animalcategory in storage) Out(nh3_ndairycow_grazing) + Out(nh3_ndairycow_housing_and_yard) + Out(nh3_ndairycow_storage) + Out(nh3_ndairycow_application);
share_storage_liquid-_othercattle	-	Share input storage other cattle if(Val(n_into_storage_liquid, Livestock) >0){ Sum(n_liquid_from_cattle, Livestock::OtherCattle) / Val(n_into_storage_liquid, Livestock); }else{0;};
nh3_notherpig_application-_liquid	kg N /a	Annual NH3 emission from application liquid (estimation proportional to input of animalcategory in storage) Out(share_application_liquid_otherpig) × Val(nh3_napplication_liquid, Application);
nh3_nsmall_ruminant-_application	kg N /a	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) Out(nh3_nsmall_ruminant_application_solid) + Out(nh3_nsmall_ruminant_application_liquid);
nh3_npig_total	kg N /a	Annual NH3 emission from pig (Application and storage, estimation proportional to input of animalcategory in storage) Out(nh3_npig_grazing) + Out(nh3_npig_housing_and_yard) + Out(nh3_npig_storage) + Out(nh3_npig_application);
nh3_nother_total	kg N /a	Annual NH3 emission from other (Application and storage, estimation proportional to input of animalcategory in storage) Out(nh3_nother_grazing) + Out(nh3_nother_housing_and_yard) + Out(nh3_nother_storage) + Out(nh3_nother_application);
nh3_npig_storage_liquid	kg N /a	Annual NH3 emission from storage liquid (estimation proportional to input of animalcategory in storage) Out(share_storage_liquid_pig) × Val(nh3_nstorage_liquid, Storage);
share_storage_solid-_othercattle	-	Share input storage other cattle if(Val(tan_into_storage_solid_dairycows_cattle, Livestock) >0){ Sum(tan_solid_from_cattle, Livestock::OtherCattle) / Val(tan_into_storage_solid_dairycows_cattle, Livestock); }else{0;};

nh3_npig_application	kg N /a	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) Out(share_storage_pig) × Val(nh3_napplication, Application);
nh3_ncattle_housing_and-_yard	kg N /a	Annual NH3 emission from cattle from all housings and yards. Sum(nh3_nhousing, Livestock::OtherCattle::Housing) + Sum(nh3_nhousing, Livestock::DairyCow::Housing) + Sum(nh3_nyard, Livestock::OtherCattle::Yard) + Sum(nh3_nyard, Livestock::DairyCow::Yard);
share_application_liquid-_dairycow	-	Share input Storage dairy cow if(Out(sum_weight_application_slurry) >0){ Sum(n_liquid_from_dairycow, Livestock::DairyCow)×0.5 / Out(sum_weight_application_slurry); }else{0;};
n_excretion_cattle	kg N /a	Total annual N excreted by all cattle (dairy cows and other cattle). Sum(n_excretion, Livestock::OtherCattle) + Sum(n_excretion, Livestock::DairyCow)
share_storage_liquid-_dairycow	-	Share input Storage dairy cow if(Val(n_into_storage_liquid, Livestock) >0){ Sum(n_liquid_from_dairycow, Livestock::DairyCow) / Val(n_into_storage_liquid, Livestock); }else{0;};
share_storage_liquid_cattle	%	Share input Storage liquid cattle if(Val(n_into_storage_liquid, Livestock) >0){ (Sum(n_liquid_from_dairycow, Livestock::DairyCow) + Sum(n_liquid_from_cattle, Livestock::OtherCattle)) / Val(n_into_storage_liquid, Livestock); }else{0;};
share_storage_solid-_otherpig	-	Share input storage solid pigs if(Val(tan_into_storage_solid_pigs, Livestock) >0){ Sum(tan_solid_from_pig, Livestock::Pig) / Val(tan_into_storage_solid_pigs, Livestock); }else{0;};
nh3_npoultry_housing_and-_yard	kg N /a	Annual NH3 emission from poultry from all housings and yards. Sum(nh3_nhousing, Livestock::Poultry::Housing);
nh3_nsmall_ruminant-_application_solid	kg N /a	Annual NH3 emission from application solid (estimation proportional to input of animalcategory in storage) Out(share_storage_solid_small_ruminant) × Val(nh3_nsolid_horses_otherequides_smallruminants, Application::SolidManure::Solid);
nh3_nothercattle-_application	kg N /a	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) Out(nh3_nothercattle_application_solid) + Out(nh3_nothercattle_application_liquid);
share_application_liquid-_otherpig	-	Share input Storage dairy cow if(Out(sum_weight_application_slurry) >0){ Sum(n_liquid_from_pig, Livestock::Pig)×0.3 / Out(sum_weight_application_slurry); }else{0;};
share_storage_liquid-_equides	-	Share input storage liquid equides if(Val(n_into_storage_liquid, Livestock) >0){ Sum(n_liquid_from_equides, Livestock::Equides) / Val(n_into_storage_liquid, Livestock); }else{0;};

nh3_notherpig_grazing	kg N /a	Annual NH3 emission from other pigs grazing areas. Sum(nh3_ngrazing, Livestock::Pig::Grazing)
nh3_notherpig_storage	kg N /a	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) Out(nh3_notherpig_storage_liquid) + Out(nh3_notherpig_storage_solid);
n_excretion_fatteningpig	kg N /a	Total annual N excreted by fattening pigs. Sum(n_excretion, Livestock::FatteningPigs)
nh3_notherpig_application_solid	kg N /a	Annual NH3 emission from application solid (estimation proportional to input of animalcategory in storage) Out(share_application_solid_otherpig) × Val(nh3_nsolid_dairycows_cattle_pigs, Application::SolidManure::Solid);
share_application_solid_dairycow	-	Share input Storage dairy cow if((Val(tan_into_storage_solid_dairycows_cattle, Livestock) + Val(tan_into_storage_solid_pigs, Livestock)) > 0){ Sum(tan_solid_from_dairycow, Livestock::DairyCow) / (Val(tan_into_storage_solid_dairycows_cattle, Livestock)+ Val(tan_into_storage_solid_pigs, Livestock)); }else{0;};
nh3_ndairycow_application	kg N /a	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) Out(nh3_ndairycow_application_liquid) + Out(nh3_ndairycow_application_solid);
share_application_liquid_equides	-	Share input Storage dairy cow if(Out(sum_weight_application_slurry) >0){ Sum(n_liquid_from_equides, Livestock::Equides)×0.5 / Out(sum_weight_application_slurry); }else{0;};
nh3_npoultry_storage	kg N /a	Annual NH3 emission from storage Val(nh3_npoultry, Storage::SolidManure::Poultry);
nh3_nfatteningpig_storage_solid	kg N /a	Annual NH3 emission from storage solid (estimation proportional to input of animalcategory in storage) Out(share_storage_solid_fatteningpig) × Val(nh3_nsolid_pigs, Storage::SolidManure::Solid);
nh3_npoultry_grazing	kg N /a	Annual NH3 emission from poultry grazing areas. Sum(nh3_nfree_range, Livestock::Poultry::Outdoor);
n_excretion_dairycow	kg N /a	Total annual N excreted by all dairy cows. Sum(n_excretion, Livestock::DairyCow);
nh3_nfatteningpig_application_solid	kg N /a	Annual NH3 emission from application solid (estimation proportional to input of animalcategory in storage) Out(share_application_solid_fatteningpig) × Val(nh3_nsolid_dairycows_cattle_pigs, Application::SolidManure::Solid);
nh3_nequides_storage_solid	kg N /a	Annual NH3 emission from storage solid (estimation proportional to input of animalcategory in storage) Out(share_storage_solid_equides) × Val(nh3_nsolid_horses_otherequides_smallruminants, Storage::SolidManure::Solid);
share_storage_solid_pig	%	Share input storage solid all pigs if(Val(n_into_storage_solid, Livestock) > 0){ (Sum(n_solid_from_pig, Livestock::Pig) + Sum(n_solid_from_fattening_pig, Livestock::FatteningPigs)) / Val(n_into_storage_solid, Livestock); } else {0;};

nh3_notherpig_storage-_solid	kg N /a	Annual NH3 emission from storage solid (estimation proportional to input of animalcategory in storage) Out(share_storage_solid_otherpig) × Val(nh3_nsolid_pigs, Storage::SolidManure::Solid);
nh3_ncattle_grazing	kg N /a	Annual NH3 emission from cattle grazing areas. Sum(nh3_ngrazing, Livestock::OtherCattle::Grazing) + Sum(nh3_ngrazing, Livestock::DairyCow::Grazing)
n_excretion_othercattle	kg N /a	Total annual N excreted by all other cattle. Sum(n_excretion, Livestock::OtherCattle)
nh3_nother_application-_liquid	kg N /a	Annual NH3 emission from application liquid (estimation proportional to input of animalcategory in storage) 0;
nh3_ncattle_application	kg N /a	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) Out(share_storage_cattle) × Val(nh3_napplication, Application);
nh3_ncattle_application-_liquid	kg N /a	Annual NH3 emission from application liquid (estimation proportional to input of animalcategory in storage) Out(nh3_ndairycow_application_liquid) + Out(nh3_nothercattle_application_liquid)
nh3_nsmall_ruminant_total	kg N /a	Annual NH3 emission from equides (Application and storage, estimation proportional to input of animalcategory in storage) Out(nh3_nsmall_ruminant_grazing) + Out(nh3_nsmall_ruminant_housing_and_yard) + Out(nh3_nsmall_ruminant_storage) + Out(nh3_nsmall_ruminant_application);
nh3_npig_application_solid	kg N /a	Annual NH3 emission from application solid (estimation proportional to input of animalcategory in storage) Out(share_storage_solid_pig) × Val(nh3_napplication_solid, Application);
share_storage_liquid-_otherpig	-	Share input storage liquid pigs if(Val(n_into_storage_liquid, Livestock) >0){ Sum(n_liquid_from_pig, Livestock::Pig) / Val(n_into_storage_liquid, Livestock); }else{0;};
nh3_nother_grazing	kg N /a	Annual NH3 emission from equides and small ruminants grazing areas. Sum(nh3_ngrazing, Livestock::Equides::Grazing) + Sum(nh3_ngrazing, Livestock::SmallRuminants::Grazing)
nh3_nsmall_ruminant-_storage	kg N /a	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) Out(nh3_nsmall_ruminant_storage_liquid) + Out(nh3_nsmall_ruminant_storage_solid);
nh3_nfatteningpig_storage-_liquid	kg N /a	Annual NH3 emission from storage liquid (estimation proportional to input of animalcategory in storage) Out(share_storage_liquid_fatteningpig) × Val(nh3_nstorage_liquid, Storage);
share_storage_solid_cattle	%	Share input Storage solid cattle if(Val(n_into_storage_solid, Livestock) >0){ (Sum(n_solid_from_dairycow, Livestock::DairyCow) + Sum(n_solid_from_cattle, Livestock::OtherCattle)) / Val(n_into_storage_solid, Livestock); }else{0;};

nh3_ncattle_storage	kg N /a	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) Out(share_storage_cattle) × Val(nh3_nstorage, Storage);
nh3_nequides_grazing	kg N /a	Annual NH3 emission from equides grazing areas. Sum(nh3_ngrazing, Livestock::Equides::Grazing)
share_storage_other	%	Share input storage equides and small ruminats if(Val(n_into_storage, Livestock) > 0){ (Sum(n_from_equides, Livestock::Equides) + Sum(n_from_other, Livestock::SmallRuminants)) / Val(n_into_storage, Livestock); }else{0;};
nh3_nfatteningpig-_application_liquid	kg N /a	Annual NH3 emission from application liquid(estimation proportional to input of animalcategory in storage) Out(share_application_liquid_fatteningpig) × Val(nh3_napplication_liquid, Application);
nh3_nsmall_ruminant-_grazing	kg N /a	Annual NH3 emission from small ruminants grazing areas. Sum(nh3_ngrazing, Livestock::SmallRuminants::Grazing)
nh3_nothercattle_storage-_solid	kg N /a	Annual NH3 emission from storage (estimation proportional to tan input of animalcategory in storage) Out(share_storage_solid_othercattle) × Val(nh3_nsolid_dairycows_cattle, Storage::SolidManure::Solid);
nh3_ncattle_total	kg N /a	Annual NH3 emission from cattle (Application and storage, estimation proportional to input of animalcategory in storage) Out(nh3_ncattle_grazing) + Out(nh3_ncattle_housing_and_yard) + Out(nh3_ncattle_storage) + Out(nh3_ncattle_application);

share_application_solid-_othercattle	-	Share input storage other cattle
		
		if((Val(tan_into_storage_solid_dairycows_cattle, Livestock) +
		Val(tan_into_storage_solid_pigs, Livestock)) > 0){
		Sum(tan_solid_from_cattle, Livestock::OtherCattle)
		/ (Val(tan_into_storage_solid_dairycows_cattle, Livestock)+
		Val(tan_into_storage_solid_pigs, Livestock));
		}else{0;};

nh3_nothercattle_total	kg N /a	Annual NH3 emission from other cattle (Application and storage, estimation proportional to input of animalcategory in storage) Out(nh3_nothercattle_grazing) + Out(nh3_nothercattle_housing_and_yard) + Out(nh3_nothercattle_storage) + Out(nh3_nothercattle_application);
nh3_ndairycow_storage-_liquid	kg N /a	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) Out(share_storage_liquid_dairycow) × Val(nh3_nstorage_liquid, Storage);
nh3_ndairycow_application-_solid	kg N /a	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) Out(share_application_solid_dairycow) × Val(nh3_nsolid_dairycows_cattle_pigs, Application::SolidManure::Solid);
nh3_nequides_storage-_liquid	kg N /a	Annual NH3 emission from storage liquid (estimation proportional to input of animalcategory in storage) Out(share_storage_liquid_equides) × Val(nh3_nstorage_liquid, Storage);
n_excretion_otherpig	kg N /a	Total annual N excreted by all other pigs. Sum(n_excretion, Livestock::Pig)
nh3_notherpig_application	kg N /a	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) Out(nh3_notherpig_application_liquid) +Out(nh3_notherpig_application_solid);

share_application_liquid_small_ruminant	-	Share input Storage dairy cow if(Out(sum_weight_application_slurry) >0){ Sum(n_liquid_from_other, Livestock::SmallRuminants)×0.5 / Out(sum_weight_application_slurry); }else{0;};
nh3_nsmall_ruminant_application_liquid	kg N /a	Annual NH3 emission from application liquid (estimation proportional to input of animalcategory in storage) Out(share_application_liquid_small_ruminant) × Val(nh3_napplication_liquid, Application);
nh3_ndairycow_application_liquid	kg N /a	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) Out(share_application_liquid_dairycow) × Val(nh3_napplication_liquid, Application);
nh3_nfatteningpig_application	kg N /a	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) Out(nh3_nfatteningpig_application_solid) + Out(nh3_nfatteningpig_application_liquid);
nh3_nothercattle_storage_liquid	kg N /a	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) Out(share_storage_liquid_othercattle) × Val(nh3_nstorage_liquid, Storage);
nh3_npig_application_liquid	kg N /a	Annual NH3 emission from application liquid (estimation proportional to input of animalcategory in storage) Out(nh3_notherpig_application_liquid) + Out(nh3_nfatteningpig_application_liquid)
share_storage_liquid_pig	%	Share input storage liquid all pigs if(Val(n_into_storage_liquid, Livestock) > 0){ (Sum(n_liquid_from_pig, Livestock::Pig) + Sum(n_liquid_from_fattening_pig, Livestock::FatteningPigs)) / Val(n_into_storage_liquid, Livestock); } else {0;};
nh3_nother_housing_and_yard	kg N /a	Annual NH3 emission from equides and small ruminants from all housings and yards. Sum(nh3_nhousing, Livestock::SmallRuminants::Housing) + Sum(nh3_nhousing, Livestock::Equides::Housing) + Sum(nh3_nyard, Livestock::Equides::Yard);
sum_weight_application_slurry	-	Sum of weight factor for slurry application between pigs and Cattle (Val(n_into_storage_liquid_pigs, Livestock)×0.35 + (Val(n_into_storage_liquid, Livestock) - Val(n_into_storage_liquid_pigs, Livestock))×0.5);
nh3_npig_housing_and_yard	kg N /a	Annual NH3 emission from all pigs from all housings and yards. Sum(nh3_nhousing, Livestock::Pig::Housing) + Sum(nh3_nhousing, Livestock::FatteningPigs::Housing)
nh3_nfatteningpig_housing_and_yard	kg N /a	Annual NH3 emission from fattening pigs from all housings and yards. Sum(nh3_nhousing, Livestock::FatteningPigs::Housing)
nh3_ncattle_application_solid	kg N /a	Annual NH3 emission from application solid (estimation proportional to input of animalcategory in storage) Out(share_storage_solid_cattle) × Val(nh3_napplication_solid, Application);
nh3_npig_grazing	kg N /a	Annual NH3 emission from all pigs grazing areas. Sum(nh3_ngrazing, Livestock::Pig::Grazing) + Sum(nh3_ngrazing, Livestock::FatteningPigs::Grazing)

share_storage_solid_fatteningpig	-	Share input storage solid pigs if(Val(tan_into_storage_solid_pigs, Livestock)>0){ Sum(tan_solid_from_fattening_pig, Livestock::FatteningPigs) / Val(tan_into_storage_solid_pigs, Livestock); }else{0;};
share_storage_liquid_small_ruminant	-	Share input storage liquid small ruminants if(Val(n_into_storage_liquid, Livestock) >0){ Sum(n_liquid_from_other, Livestock::SmallRuminants) / Val(n_into_storage_liquid, Livestock); }else{0;};
nh3_nfatteningpig_total	kg N /a	Annual NH3 emission from pig (Application and storage, estimation proportional to input of animalcategory in storage) Out(nh3_nfatteningpig_grazing) + Out(nh3_nfatteningpig_housing_and_yard) + Out(nh3_nfatteningpig_storage) + Out(nh3_nfatteningpig_application);
nh3_nequides_application_liquid	kg N /a	Annual NH3 emission from application liquid (estimation proportional to input of animalcategory in storage) Out(share_application_liquid_equides) × Val(nh3_napplication_liquid, Application);
nh3_ndairycow_storage	kg N /a	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) Out(nh3_ndairycow_storage_liquid) + Out(nh3_ndairycow_storage_solid)
nh3_nequides_storage	kg N /a	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) Out(nh3_nequides_storage_solid) + Out(nh3_nequides_storage_liquid);
share_application_liquid_othercattle	-	Share input Storage dairy cow if(Out(sum_weight_application_slurry) >0){ Sum(n_liquid_from_cattle, Livestock::OtherCattle)×0.5 / Out(sum_weight_application_slurry); }else{0;};
nh3_ncattle_storage_liquid	kg N /a	Annual NH3 emission from storage liquid (estimation proportional to input of animalcategory in storage) Out(share_storage_liquid_cattle) × Val(nh3_nstorage_liquid, Storage);
share_storage_liquid_fatteningpig	-	Share input storage liquid pigs if(Val(n_into_storage_liquid, Livestock)>0){ Sum(n_liquid_from_fattening_pig, Livestock::FatteningPigs) / Val(n_into_storage_liquid, Livestock); }else{0;};
n_excretion_pig	kg N /a	Total annual N excreted by all pigs (pigs and fattening pigs). Sum(n_excretion, Livestock::Pig) + Sum(n_excretion, Livestock::FatteningPigs)
n_excretion_other	kg N /a	Total annual N excreted by all equides and small ruminants. Sum(n_excretion, Livestock::Equides) + Sum(n_excretion, Livestock::SmallRuminants)
nh3_nother_storage_liquid	kg N /a	Annual NH3 emission from storage liquid (estimation proportional to input of animalcategory in storage) Out(share_storage_liquid_other) × Val(nh3_nstorage_liquid, Storage);
nh3_nother_application	kg N /a	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) Val(nh3_nsolid_horses_otherequides_smallruminants, Application::SolidManure::Solid);

nh3_nothercattle_housing_and_yard	kg N /a	Annual NH3 emission from cattle from all housings and yards. Sum(nh3_nhousing, Livestock::OtherCattle::Housing) + Sum(nh3_nyard, Livestock::OtherCattle::Yard)
nh3_ncattle_storage_solid	kg N /a	Annual NH3 emission from storage solid (estimation proportional to input of animalcategory in storage) Out(share_storage_solid_cattle) × Val(nh3_nstorage_solid, Storage);
share_storage_pig	%	Share input storage all pigs if(Val(n_into_storage, Livestock) > 0){ (Sum(n_from_pig, Livestock::Pig) + Sum(n_from_fattening_pig, Livestock::FatteningPigs)) / Val(n_into_storage, Livestock); } else {0;};
nh3_nother_application_solid	kg N /a	Annual NH3 emission from application solid (estimation proportional to input of animalcategory in storage) Val(nh3_nsolid_horses_otherequides_smallruminants, Application::SolidManure::Solid);
share_storage_liquid_other	%	Share input storage liquid equides and small ruminats if(Val(n_into_storage_liquid, Livestock) > 0){ (Sum(n_liquid_from_equides, Livestock::Equides) + Sum(n_liquid_from_other, Livestock::SmallRuminants)) / Val(n_into_storage_liquid, Livestock); }else{0;};
nh3_nothercattle_application_solid	kg N /a	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) Out(share_application_solid_othercattle) × Val(nh3_nsolid_dairycows_cattle_pigs, Application::SolidManure::Solid);
nh3_npoultry_application	kg N /a	Annual NH3 emission from application Val(nh3_npoultry, Application::SolidManure::Poultry);
nh3_nothercattle_grazing	kg N /a	Annual NH3 emission from other cattle grazing areas. Sum(nh3_ngrazing, Livestock::OtherCattle::Grazing)
share_application_liquid_fatteningpig	-	Share input Storage dairy cow if(Out(sum_weight_application_slurry) >0){ Sum(n_liquid_from_fattening_pig, Livestock::FatteningPigs)×0.3 / Out(sum_weight_application_slurry); }else{0;};
share_storage_solid_equides	-	Share input storage solid equides if(Val(tan_into_storage_solid_horses_otherequides_smallruminants, Livestock) >0){ Sum(tan_solid_from_equides, Livestock::Equides) / Val(tan_into_storage_solid_horses_otherequides_smallruminants, Livestock); }else{0;};
share_storage_solid_small_ruminant	-	Share input storage solid small ruminants if(Val(tan_into_storage_solid_horses_otherequides_smallruminants, Livestock) >0){ Sum(tan_solid_from_other, Livestock::SmallRuminants) / Val(tan_into_storage_solid_horses_otherequides_smallruminants, Livestock); }else{0;};
nh3_nequides_housing_and_yard	kg N /a	Annual NH3 emission from equides from all housings and yards. Sum(nh3_nhousing, Livestock::Equides::Housing) + Sum(nh3_nyard, Livestock::Equides::Yard);

nh3_nsmall_ruminant-_storage_liquid	kg N /a	Annual NH3 emission from storage liquid (estimation proportional to input of animalcategory in storage) Out(share_storage_liquid_small_ruminant) × Val(nh3_nstorage_liquid, Storage);
nh3_notherpig_total	kg N /a	Annual NH3 emission from pig (Application and storage, estimation proportional to input of animalcategory in storage) Out(nh3_notherpig_grazing) + Out(nh3_notherpig_housing_and_yard) + Out(nh3_notherpig_storage) + Out(nh3_notherpig_application);
nh3_nothercattle_storage	kg N /a	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) Out(nh3_nothercattle_storage_solid) + Out(nh3_nothercattle_storage_liquid);
n_excretion_poultry	kg N /a	Total annual N excreted by all poultry animals. Sum(n_excretion, Livestock::Poultry)
nh3_nequides_application	kg N /a	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) Out(nh3_nequides_application_solid) + Out(nh3_nequides_storage_liquid);
nh3_ndairycow_storage-_solid	kg N /a	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) Out(share_storage_solid_dairycow) × Val(nh3_nsolid_dairycows_cattle, Storage::SolidManure::Solid);
share_storage_solid_other	%	Share input storage solid equides and small ruminats if(Val(n_into_storage_solid, Livestock) > 0){ (Sum(n_solid_from_equides, Livestock::Equides) + Sum(n_solid_from_other, Livestock::SmallRuminants)) / Val(n_into_storage_solid, Livestock); }else{0;};
nh3_nfatteningpig_grazing	kg N /a	Annual NH3 emission from fattening pigs grazing areas. Sum(nh3_ngrazing, Livestock::FatteningPigs::Grazing)
n_excretion_small-_ruminants	kg N /a	Total annual N excreted by all small ruminants. Sum(n_excretion, Livestock::SmallRuminants)
nh3_nothercattle-_application_liquid	kg N /a	Annual NH3 emission from application (estimation proportional to input of animalcategory in storage) Out(share_application_liquid_othercattle) × Val(nh3_napplication_liquid, Application);
n_excretion_equides	kg N /a	Total annual N excreted by all equides. Sum(n_excretion, Livestock::Equides)
nh3_nsmall_ruminant-_storage_solid	kg N /a	Annual NH3 emission from storage solid (estimation proportional to input of animalcategory in storage) Out(share_storage_solid_small_ruminant) × Val(nh3_nsolid_horses_otherequides_smallruminants, Storage::SolidManure::Solid);
nh3_ndairycow_housing-_and_yard	kg N /a	Annual NH3 emission from dairy cows from all housings and yards. Sum(nh3_nhousing, Livestock::DairyCow::Housing) + Sum(nh3_nyard, Livestock::DairyCow::Yard);
nh3_npig_storage	kg N /a	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) Out(share_storage_pig) × Val(nh3_nstorage, Storage);

nh3_nother_storage_solid	kg N /a	Annual NH3 emission from storage solid (estimation proportional to input of animalcategory in storage) Out(share_storage_solid_other) × Val(nh3_nstorage_solid, Storage);
nh3_nequides_total	kg N /a	Annual NH3 emission from equides (Application and storage, estimation proportional to input of animalcategory in storage) Out(nh3_nequides_grazing) + Out(nh3_nequides_housing_and_yard) + Out(nh3_nequides_storage) + Out(nh3_nequides_application);
nh3_npoultry_total	kg N /a	Annual NH3 emission from pig (Application and storage, estimation proportional to input of animalcategory in storage) Out(nh3_npoultry_grazing) + Out(nh3_npoultry_housing_and_yard) + Out(nh3_npoultry_storage) + Out(nh3_npoultry_application);
share_storage_solid-_dairycow	-	Share input Storage dairy cow if(Val(tan_into_storage_solid_dairycows_cattle, Livestock) >0){ Sum(tan_solid_from_dairycow, Livestock::DairyCow) / Val(tan_into_storage_solid_dairycows_cattle, Livestock); }else{0;};
share_storage_cattle	%	Share input Storage cattle if(Val(n_into_storage, Livestock) >0){ (Sum(n_from_dairycow, Livestock::DairyCow) + Sum(n_from_cattle, Livestock::OtherCattle)) / Val(n_into_storage, Livestock); }else{0;};
nh3_ndairycow_grazing	kg N /a	Annual NH3 emission from dairy cows grazing areas. Sum(nh3_ngrazing, Livestock::DairyCow::Grazing);
nh3_nother_storage	kg N /a	Annual NH3 emission from storage (estimation proportional to input of animalcategory in storage) Out(share_storage_other) × Val(nh3_nstorage, Storage);
nh3_nequides_application-_solid	kg N /a	Annual NH3 emission from application solid (estimation proportional to input of animalcategory in storage) Out(share_storage_solid_equides) × Val(nh3_nsolid_horses_otherequides_smallruminants, Application::SolidManure::Solid);

share_application_solid-_otherpig	-	Share input storage solid pigs
		
		if((Val(tan_into_storage_solid_dairycows_cattle, Livestock) +
		Val(tan_into_storage_solid_pigs, Livestock)) >0){
		Sum(tan_solid_from_pig, Livestock::Pig)
		/ (Val(tan_into_storage_solid_dairycows_cattle, Livestock)+
		Val(tan_into_storage_solid_pigs, Livestock));
		}else{0;};

share_application_solid-_fatteningpig	-	Share input storage solid pigs
		
		if((Val(tan_into_storage_solid_dairycows_cattle, Livestock) +
		Val(tan_into_storage_solid_pigs, Livestock)) > 0){
		Sum(tan_solid_from_fattening_pig, Livestock::FatteningPigs)
		/ (Val(tan_into_storage_solid_dairycows_cattle, Livestock)+
		Val(tan_into_storage_solid_pigs, Livestock));
		}else{0;};

nh3_nsmall_ruminant-_housing_and_yard	kg N /a	Annual NH3 emission from small ruminants from all housings and yards. Sum(nh3_nhousing, Livestock::SmallRuminants::Housing)
nh3_notherpig_storage-_liquid	kg N /a	Annual NH3 emission from storage liquid (estimation proportional to input of animalcategory in storage) Out(share_storage_liquid_otherpig) × Val(nh3_nstorage_liquid, Storage);

nh3_notherpig_housing-_and_yard	kg N /a	Annual NH3 emission from other pigs form all housings and yards. Sum(nh3_nhousing, Livestock::Pig::Housing)

98.5 Detailed process description

99 Total

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99.1 Short description

Summarize the Annual emissions from an Farm.

99.2 Input parameters

99.3 Technical parameters

99.4 Output

Parameter	Unit	Formula
nh3_ntotal	kg N /a	Annual NH3 emission from farm. Val('nh3_napplication', Application) + Val('nh3_nstorage', Storage) + Val('nh3_nlivestock', Livestock) + Val('nh3_nplantproduction', PlantProduction)
nh3_nanimalproduction	kg N /a	Annual NH3 emission from farm. Val('nh3_napplication', Application) + Val('nh3_nstorage', Storage) + Val('nh3_nlivestock', Livestock)

99.5 Detailed process description

This process summarizes the contribution of the individual Modules to the total NH3 emission from a farm.

100 Input Parameters

Parameter	Unit	Description

Livestock::Poultry::Excretion

animalcategory	-	Poultry category (layers, growers, broilers, turkeys, and other poultry). Possible values: `broilers`, `growers`, `other_poultry`, `turkeys`, `layers`
animals	-	Number of poultry animals for the selected type in barn.

Livestock::Poultry::Outdoor

free_range	-	Average free range hours per day. Possible values: `no`, `yes`

Livestock::Poultry::Housing::Type

housing_type	-	Type of housing. Possible values: `deep_litter`, `deep_pit`, `manure_belt`
manure_removal_interval	-	Manure removal interval by manure belt. Possible values: `3_to_4_times_a_month`, `more_than_4_times_a_month`, `no_manure_belt`, `twice_a_month`, `less_than_twice_a_month`
drinking_system	-	Type of drinking system. Possible values: `bell_drinkers`, `drinking_nipples`

Livestock::Poultry::Housing::AirScrubber

air_scrubber	-	Exhaust air scrubber: none, acid, biotrickling_filter. Possible values: `acid`, `biotrickling`, `none`

Storage::SolidManure::Poultry

share_applied_direct_poultry-_manure	%	Share of poultry manure applied to land without storage.
share_covered_basin	%	Share of droppings or mist from poultry stored in covered basin.

Storage::SolidManure::Solid

share_applied_direct_cattle-_other_manure	%	Share of cattle manure applied to land without storage.

Parameter	Unit	Description
share_applied_direct_pig_manure	%	Share of pig manure applied to land without storage.

Application::Slurry::Ctech

share_splash_plate	%	Share of slurry applied with splash plate.
share_trailing_hose	%	Share of slurry applied with trailing hose.
share_trailing_shoe	%	Share of slurry applied with trailing shoes.
share_shallow_injection	%	Share of slurry applied with shallow injection.
share_deep_injection	%	Share of slurry applied with deep injection.

Application::Slurry::Applrate

dilution_parts_water	1:x	Specific slurry dilution. TAN contents have been calculated based on a standard dilution of 1:1 with a TAN content of 1.15 kg N /m3.
appl_rate	m3 /ha	Application rate, mean volume of slurry applied on a ha per deployment.

Application::Slurry::Csoft

appl_evening	%	Share of slurry applied in the evening after 18:00.
appl_hotdays	-	Proportion of slurry applied on hot days. Possible values: `never`, `rarely`, `sometimes`, `frequently`

Application::Slurry::Cseason

appl_summer	%	Share of slurry applied June to August (in %).
appl_autumn_winter_spring	%	Share of slurry applied September to May.

Application::SolidManure::CincorpTime

incorp_lw1h	%	Share of incorporated solid manure within 1 hour.
incorp_lw4h	%	Share of incorporated solid manure within 4 hours.
incorp_lw8h	%	Share of incorporated solid manure within 8 hours.
incorp_lw1d	%	Share of incorporated solid manure within 1 day.
incorp_lw3d	%	Share of incorporated solid manure within 3 days.
incorp_gt3d	%	Share of incorporated solid manure after 3 days.
incorp_none	%	Share of solid manure not incorporated.

Application::SolidManure::Cseason

appl_summer	%	Share of solid manure applied June to August (in %).
appl_autumn_winter_spring	%	Share of solid manure applied September to May (in %).

PlantProduction::AgriculturalArea

Parameter	Unit	Description
agricultural_area	ha	Agricultural area.

PlantProduction::MineralFertiliser

mineral_nitrogen_fertiliser_urea	kg N /a	Amount of urea in kg N /a.
mineral_nitrogen_fertiliser-_except_urea	kg N /a	Amount of nitrogen fertiliser (except urea) in kg N /a.

PlantProduction::RecyclingFertiliser

compost	t /a	Amount of compost (in t fresh matter per year). Kompost besteht aus Grünabfällen nicht-landwirtschaftlicher Herkunft von gewerblich-industriellen Anlagen oder von Feldrandkompostierung.
solid_digestate	t /a	Amount of solid digestate form industrial factories.
liquid_digestate	m3 /a	Amount of liquid digestate form industrial factories.

101 Technical Parameters

Parameter	Value	Unit	Description

Livestock::Poultry::Excretion

standard_N_excretion_layers	0.80	kg N /a	Annual standard N excretion for poultry category (layers) according to Flisch et al. (2009).
standard_N_excretion_growers	0.34	kg N /a	Annual standard N excretion for poultry category (growers) according to Flisch et al. (2009).
standard_N_excretion_broilers	0.45	kg N /a	Annual standard N excretion for poultry category (broilers) according to Flisch et al. (2009).
standard_N_excretion_turkeys	1.4	kg N /a	Annual standard N excretion for poultry category according (turkeys) to Flisch et al. (2009).
standard_N_excretion_other-_poultry	0.56	kg N /a	Annual standard N excretion for other poultry category according to Flisch et al. (2009).
share_Nsol_layers	0.6	-	Nsol content of excreta for layers. Derived from e.g. TODO
share_Nsol_growers	0.6	-	Nsol content of excreta for growers. Derived from e.g. TODO
share_Nsol_broilers	0.6	-	Nsol content of excreta for broilers. Derived from e.g. TODO
share_Nsol_turkeys	0.6	-	Nsol content of excreta for turkeys. Derived from e.g. TODO
share_Nsol_other_poultry	0.6	-	Nsol content of excreta for other poultry. Derived from e.g. TODO

Livestock::Poultry::Outdoor

er_free_range	0.7	-	Emission rate for free range poultry, based on Menzi et al. (1997): 70% of TAN or 28% of Ntot
free_range_days_layers	280	d /a	Average free range days per year.
free_range_hours_layers	2.88	h /d	Average free range hours per day, assumed is 12% of Day
free_range_days_growers	280	d /a	Average free range days per year.
free_range_hours_growers	2.88	h /d	Average free range hours per day, assumed is 12% of Day

Parameter	Value	Unit	Description
free_range_days_turkeys	280	d /a	Average free range days per year.
free_range_hours_turkeys	0.96	h /d	Average free range hours per day, assumed is 4% of Day
free_range_days_other_poultry	280	d /a	Average free range days per year.
free_range_hours_other_poultry	0.96	h /d	Average free range hours per day, assumed is 12% of Day
free_range_days_broilers	280	d /a	Average free range days per year.
free_range_hours_broilers	0.96	h /d	Average free range hours per day, assumed is 4% of Day

Livestock::Poultry::Housing::Type

er_housing_layers_growers_manure_belt	0.15	-	Emission rate for the poultry housing type, based on EAGER workshop January 2007: 15% of Ntot, converted using 60% Nsol and emission factor of 25%.
er_housing_layers_growers_deep_pit	0.30	-	Emission rate for the poultry housing type, based on EAGER workshop January 2007, UNECE 2007: 30% of Ntot, converted using 60% Nsol and emission factor of 50%.
er_housing_layers_growers_deep_litter	0.30	-	Emission rate for the poultry housing type, based on EAGER workshop January 2007, UNECE 2007: 30% of Ntot, converted using 60% Nsol and emission factor of 50%.
er_housing_other_deep_litter	0.12	-	Emission rate for the poultry housing type, based on Reidy et al. (2009): 12% of Ntot, converted using 60% Nsol and emission factor of 20%.
c_manure_removal_interval_less_than_twice_a_month	1.2	-	Emission rate for the poultry manure removal by droppings belt. Empirical assumption by Reidy/Menzi.
c_manure_removal_interval_twice_a_month	1	-	Emission rate for the poultry manure removal by droppings belt. Empirical assumption by Reidy/Menzi.
c_manure_removal_interval_3_to_4_times_a_month	0.8	-	Emission rate for the poultry manure removal by droppings belt. Empirical assumption by Reidy/Menzi.
c_manure_removal_interval_more_than_4_times_a_month	0.6	-	Emission rate for the poultry manure removal by droppings belt. Empirical assumption by Reidy/Menzi.
c_drinking_nipples	1.0	-	Emission rate for the poultry drinking type standard version.
c_bell_drinkers	1.2	-	Emission rate for the poultry drinking type additional emission. Empirical assumption by Reidy/Menzi.
TODO: Give better description!			

Livestock::Poultry::Housing::AirScrubber

red_acid_air_scrubber	0.9	-	Reduction efficiency as compared to group-housed on fully and partly slatted floors (UNECE 2007, paragraph 71, table 5).
red_biotrickling_filter_air_scrubber	0.7	-	Reduction efficiency as compared to group-housed on fully and partly slatted floors (UNECE 2007, paragraph 71, table 5).

Parameter	Value	Unit	Description
Storage			
mineralizationrate_liquid	0.1	-	A netto mineralization of 10% from Norg to NSol/TAN is assuemd, according to the GAS_EM Model
Storage::SolidManure::Poultry			
er_layers_growers_other_poultry	0.25	-	Emission rate for layers, growers and other poultry for manure (deep pit, deep litter) and droppings (manure belt)(based on EAGER workshop, January 2008: 15% Ntot, converted using Nsol 60% and emission factor of 25%.
er_turkeys_broilers	0.1	-	Emission rate for manure of broilers and turkeys based on EAGER workshop, January 2008: 6% Ntot, converted using Nsol 60% and emission factor of 10%.
c_droppings_mist_covered_basin	0.6	-	Reduction of emission rate for the droppings or mist stored in covered basin for poultry.
immobilizationrate_poultry	0.4	-	A netto immobilization of 40% from NSol/TAN to Norg is assuemd, according to the GAS_EM Model
Storage::SolidManure::Solid			
er_tan_pigs	0.5	-	The value has been derived from the Eager workshop, January 2008: (additional explanation following)
er_tan_cattle_other	0.3	-	The value has been derived from the Eager workshop, January 2008: (additional explanation following)
immobilizationrate_solid	0.4	-	A netto immobilization of 40% from NSol/TAN to Norg is assuemd, according to the GAS_EM Model
Application::Slurry			
er_App_cattle_liquid	0.5	-	Emission rate for slurry application based on TAN of the slurry. The average rate has been derived from Sommer (2001b), Sogaard et al. (2002), Menzi et al. (1998), Menzi et al. (1997a)
er_App_pigs_liquid	0.35	-	Die Emissionsrate wurde gemäss ALFAM Modell (Sogaard et al., 2002) berechnet mit folgenden Inputdaten: durchschnittliche Temperatur von März bis November: 12°C (Daten SMA Station Bern Liebefeld 1993-2002); Windgeschwindigkeit von 1 m/s: Schweinegülle Mast: TAN Gehalt Gülle: 2.1 kg/m3 (Verdünnung 1:1, d.h. 2.5 % TS gemäss Flisch et al., 2009); ohne Korrekturen für emissionsminderende Ausbringung, ohne Einarbeitung nach Ausbringung; Ausbringungsmenge: 30 m3/ha; mikrometeorologische Messung: 30.3 % TAN (Mittelwert Boden feucht, Boden trocken). Bei gleichen Annahmen, jedoch einer reduzierten Ausbringungsmenge von 20 m3/ha (aufgrund des im Vergleich zu Rindergülle höheren TAN-Gehalts) und eines TS Gehalts von 3 % (höherer Strohanteil bei Labelsystemen): 33.2 %. Unter den analogen Annahmen resultieren für Schweinegülle Zucht (TAN Gehalt Gülle: 1.65 kg/m3; Verdünnung 1:1, d.h. 2.5 % TS gemäss Flisch et al., 2009) Emissionsraten von 32.9 % bzw. 36.2 % TAN.

Parameter	Value	Unit	Description

Application::Slurry::Ctech

Parameter	Value	Unit	Description
red_splash_plate	0.0	-	There is no reduction for broadcasting with splash plate as to this way of applying slurry all the other methods are compared to.
red_trailing_hose	-0.3	-	Reduction efficiency as compared to broadcasting applying trailing hose. Adopted from UNECE (2007), Frick and Menzi (1997) and Menzi et al. (1997).
red_trailing_shoe	-0.5	-	Reduction efficiency as compared to broadcasting applying trailing shoe. Adopted from UNECE (2007), Frick and Menzi (1997) and Menzi et al. (1997).
red_shallow_injection	-0.7	-	Reduction efficiency as compared to broadcasting applying shallow injection. Adopted from UNECE (2007), Frick and Menzi (1997) and Menzi et al. (1997).
red_deep_injection	-0.8	-	Reduction efficiency as compared to broadcasting applying deep injection. Adopted from UNECE(2007), Frick and Menzi (1997) and Menzi et al. (1997).

Application::Slurry::Applrate

Parameter	Value	Unit	Description
norm_er	0.5	-	Standard emission of 50% of the applied TAN calculated based on an equation published by Menzi et al (1998) using a TAN standard of 1.15 kg /m3 for an 1:1 dilution, with application rate (AR) standard of 30 m3 /ha and average swiss meteorological conditions (T=12 C, humitity=70%): ((19.41 * TAN_standard + 4.2 * 1.102 - 9.51) * (0.0214 * AR-standard + 0.36) / (AR_standard * TAN-standard)))

Application::Slurry::Csoft

Parameter	Value	Unit	Description
c_evening	-0.2	-	Correction factor of the emission rate if slurry is applied in the evening (after 18h)(Menzi et al 1997; Frick and Menzi 1997). Assumption based on a single experiment with an application after 18h in August at a temperature of ¿20°C: reduction of the emission by 38%, the reduction of the emission averaged over the whole year is only 50%, i.e. -0.2 The correction is omitted for solid manure since infiltration into soil does not occur.
c_hotdays_frequently	0.1	-	Correction factor of the emission rate if slurry is applied frequently on hot days. Loss calculated according to the model of Katz (Menzi et al. 1997b) at 17°C (i.e. +5°C) compared to the reference temperature of 12°C (other parameters: 70% rela-tive air humidity, 1.15 kg/m3 TAN, 30 m3/ha) resulting in a loss of 19.22 kg N/ha at 17 °C and 55.7% TAN, respectively (compared to 17.45 kg N/ha and 50.6% TAN at 12°C, respectively) which corresponds to an increase of 10.1% (rounded to 10%).

Parameter	Value	Unit	Description
c_hotdays_sometimes	0.0	-	Correction factor of the emission rate if slurry is applied sometimes on hot days (estimation based on Menzi et al (1997)).
c_hotdays_rarely	-0.1	-	Correction factor of the emission rate if slurry is applied rarely on hot days (estimation based on Menzi et al (1997)).
c_hotdays_never	-0.2	-	Correction factor of the emission rate if slurry is applied never on hot days (estimation based on Menzi et al (1997)).

Application::Slurry::Cseason

c_summer	0.15	-	Correction factor for the application of slurry in summer (June to August): Model calculation according to the model of Katz (Menzi et al. 1997b) with meteorological data from Liebefeld 1993-2002: average from March to November 12°C, 70% relative air humidity, 1.15 kg/m3 TAN, 30 m3/ha resulting in a loss of 50.6% TAN; summer 17.8°C resulting in a loss of 56.7% TAN (+12%). Value chosen for cal-culation: +15%
c_autumn_winter_spring	-0.05	-	Correction factor for the application of slurry in autumn, winter and spring (Sept to May): Model calculation according to the model of Katz (Menzi et al. 1997b) with meteorological data from Liebefeld 1993-2002: average from March to November 12°C, 70% relative air humidity, 1.15 kg/m3 TAN, 30 m3/ha resulting in a loss of 50.6% TAN; spring/autumn/winter 9°C resulting in a loss of 48.1% TAN (-4.8%). Value chosen for calculation: -5%

Application::SolidManure::Solid

er_App_manure_dairycows-_cattle_pigs	0.8	-	Emission rate for manure application. The average rate has been derived from Frick et al. (1996) and Menzi et al. (1996). The value is based on the average emissions from diffrent Swiss experiments. Emission based on TAN of slurry.
er_App_manure_horses-_otherequides_smallruminants	0.7	-	Emission rate for manure application. The average rate has been derived from Frick et al. (1996) and Menzi et al. (1996). The value is based on the average emissions from diffrent Swiss experiments. Emission based on TAN of slurry.

Application::SolidManure::Solid::CincorpTime

eff_inc_lw1h	-0.9	-	Reduction due to incorporation of solid manure within 1 hour. UNECE (2007).
eff_inc_lw4h	-0.7	-	Reduction due to incorporation of solid manure within 4 hours. Empirical estimate deduced from UNECE (2007). Mean value between the category incorporation within 1 hour and incorporation within 8 hours.

Parameter	Value	Unit	Description
eff_inc_lw8h	-0.5	-	Reduction due to incorporation of solid manure within 8 hours. Values adapted from UNECE (2007) (category Incorporation by plough within 12 h)
eff_inc_lw1d	-0.35	-	Reduction due to incorporation of solid manure within 1 day. Values adapted from UNECE (2007) Empirical estimate deduced from Menzi et al. (1997).
eff_inc_lw3d	-0.3	-	Reduction due to incorporation of solid manure within 3 days. Empirical estimate deduced from Menzi et al. (1997).
eff_inc_gt3d	-0.1	-	Reduction due to incorporation of solid manure after 3 days Empirical estimate deduced from Menzi et al. (1997).
eff_inc_none	0.0	-	Basis with no incorporation of solid manure.

Application::SolidManure::Cseason

c_summer	0.15	-	Correction factor for the application of solid manure in summer (June to August): Model calculation according to the model of Katz (Menzi et al. 1997b) with meteorological data from Liebefeld 1993-2002: average from March to November 12°C, 70% relative air humidity, 1.15 kg/m3 TAN, 30 m3/ha resulting in a loss of 50.6% TAN; summer 17.8°C resulting in a loss of 56.7% TAN (+12%). Value chosen for cal-culation: +15%.
c_autumn_winter_spring	-0.05	-	Correction factor for the application of solid manure in autumn, winter and spring (Sept to May): Model calculation according to the model of Katz (Menzi et al. 1997b) with meteorological data from Liebefeld 1993-2002: average from March to November 12°C, 70% relative air humidity, 1.15 kg/m3 TAN, 30 m3/ha resulting in a loss of 50.6% TAN; spring/autumn/winter 9°C resulting in a loss of 48.1% TAN (-4.8%). Value chosen for calculation: -5%.

Application::SolidManure::Poultry

er_App_manure_layers_growers-_other_poultry	0.3	-	Emission rate for manure application. The average rate has been derived from Frick et al. (1996) and Menzi et al. (1997). The value is based on the average emissions from diffrent Swiss experiments. Emission based on TAN of slurry.
er_App_manure_turkeys_broilers	0.65	-	Emission rate for manure application. The average rate has been derived from Frick et al. (1996) and Menzi et al. (1997). The value is based on the average emissions from diffrent Swiss experiments. Emission based on TAN of slurry.

Parameter	Value	Unit	Description

Application::SolidManure::Poultry::CincorpTime

Parameter	Value	Unit	Description
eff_inc_lw1h	-0.95	-	Reduction due to incorporation of solid manure within 1 hour. UNECE (2007).
eff_inc_lw4h	-0.8	-	Reduction due to incorporation of solid manure within 4 hours. Empirical estimate deduced from UNECE (2007). Mean value between the category incorporation within 1 hour and incorporation within 8 hours.
eff_inc_lw8h	-0.7	-	Reduction due to incorporation of solid manure within 8 hours. Values adapted from UNECE (2007) (category Incorporation by plough within 12 h)
eff_inc_lw1d	-0.55	-	Reduction due to incorporation of solid manure within 1 day. Values adapted from UNECE (2007) Empirical estimate deduced from Menzi et al. (1997).
eff_inc_lw3d	-0.3	-	Reduction due to incorporation of solid manure within 3 days. Empirical estimate deduced from Menzi et al. (1997).
eff_inc_gt3d	-0.1	-	Reduction due to incorporation of solid manure after 3 days Empirical estimate deduced from Menzi et al. (1997).
eff_inc_none	0.0	-	Basis with no incorporation of solid manure.

PlantProduction::AgriculturalArea

Parameter	Value	Unit	Description
er_agricultural_area	2	kg N /ha /a	Emission rate from the agricultural area. The average rate has been derived from Schjoerring and Mattson (2001). Emission based on kg/ ha AA (AA = agricultural area, Landwirschaftliche Nutzfläche). N ist NH3 N.

PlantProduction::MineralFertiliser

Parameter	Value	Unit	Description
er_App_mineral_nitrogen-_fertiliser_urea	0.15	-	Emission rate for the application of urea. The average rate has been derived from Vanderweerden and Jarvis (1997). Emission based on Ntot.
er_App_mineral_nitrogen-_fertiliser_except_urea	0.02	-	Emission rate for the application of ammonium nitrate. The average rate has been derived from Vanderweerden and Jarvis (1997). Emission based on Ntot.

PlantProduction::RecyclingFertiliser

Parameter	Value	Unit	Description
er_compost 0.3 kg TAN per t fresh matter (Flisch et al., 2009). of TAN.	0.24	kg N / t	Emission rate from compost, calculated with an emission rate of 80
er_solid_digestate	0.24	kg N / t	Emission rate for solid digestat from industrial plantse, calculated with an emmission rate of 80
er_liquid_digestate	1.2	kg N / t	Emission rate from liquid digestate from industrial plants, calculated with an emmission rate of 60

Parameter	Value	Unit	Description