



MANURE STANDARDS PUBLICATION



Instructions for Using Regional Manure Calculation Tool

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Preface

The tool allows calculation of the annual livestock manure production and properties (total nitrogen, phosphorus, and potassium quantity and concentration) and nitrogen losses at regional (state) level. Depending on the accuracy of the data, calculations can be made on three levels of accuracy (Tier 1, 2 and 3). The Tier 1 calculation is based on the animal categories and methods listed in the EMEP/EEA air pollutant emission inventory Guidebook (2016). Tier 2 uses national excretion values for ex-animal level and calculates the further calculations as a mass balance (ex-housing, ex-storage). Tier 3 is a full mass balance calculation using the ex-animal algorithms of the Danish normative manure system (DIAS report no 7).

Legend

The meaning of colors in the tables:

Yellow fields – automatically calculated values;

Green fields – values from the user (input data);

White, **grey** and **brown** fields – white fields are hidden columns with intermediate calculations and formulas; values are taken from the databases of the tool (sheets “DB animal categories”, “DB technologies” and “DB additional information”).

Only green, white, grey and brown cells are open for the user, all other cells are locked (protected with password).

Manure Standards is co-funded by the Interreg Baltic Sea Region Programme. It is coordinated by Natural Resources Institute Finland (Luke) and includes partners from 9 countries around the Baltic Sea: Finland, Sweden, Denmark, Germany, Poland, Lithuania, Latvia, Russia and Estonia. The project is a Flagship of the EU Strategy for the Baltic Sea Region. More information at www.luke.fi/manurestandards.

1 Databases

1.1 Animal categories (Sheet “DB animal categories”, table “Database: Animal categories and default values”)

1.1.1 Calculation method “Tier 1”

The “Tier 1” calculation is based on the animal categories and methods listed in the EMEP/EEA air pollutant emission inventory Guidebook (2016). The location and the name of the group of animals (by manure type) in the database (table) is fixed and not editable (Figure 1.A). Information needed for “Tier 1” calculation is described in the brown fields, columns AD – AN (Figure 1.B). The source of the information used can be e.g. regional averages or international handbooks. If animals are not grazing (there is no access to pasture and outdoor areas), corresponding fields (columns AI – AM) will stay empty.

Cattle	Animal category	Tier 1							
		Manure (ex-animal)				Manure (grazing)			
		Quantity	N	P	K	Quantity	N	P	K
		Total				Total			
		t/year	kg/year			t/year	kg/year		
									Manure DM ex-animal %
Cows	Slurry (Tier1)	22,9	134,0	30,1	101,0				15,3
	Solid (Tier1)	22,9	134,0	30,1	101,0	3,8	22,0	4,9	16,6
	1.A								
		1.B							

Figure 1.A Location of the groups of animals, **1.B** Information needed for “Tier” 1 calculation at ex-animal level

1.1.2 Calculation method “Tier 2”

The “Tier 2” calculation is based on the regional average (table) values of excreted manure (ex-animal) by animal species and age groups. It is recommended to use the indicators that are fixed in official region-based documents. If an animal group is divided into subgroups on the basis of some parameter, the number of subgroups can be maximum 10.

The names and the locations of a subgroup in the table (column C, white fields) are not fixed (Figure 2.A). Information needed for “Tier 2” calculation is described in the light grey fields, columns P – Z and AA - AC (Figure 2.B). All groups and information added to the table is available in the calculations. The example values are based on the grouping of dairy cows used in Denmark and their corresponding average values. If animals are not grazing (there is no access to pasture and outdoor areas), the corresponding fields in columns AA (days per year) and AB (hours per day) stay empty. Fields in the column AC “Rearing period” (days/year) must always be filled. As the calculations are characterized by the production of manure per year, ‘365’ days should be used for animals with a rearing period of more than one year, and a feasible amount of days for animals with a shorter rearing period than one year.

Cattle	Animal category	Tier 2					Tier 2,3		
		Manure (ex-animal)					Grazing		Rearing
		Quantity	DM	N	P	K	days/ year	hours/ day	period
		t/year	%	Total		kg/year			days/ year
Cows	Slurry (Tier1)								
	Solid (Tier1)								
	Heavy breeds	26,0	10,5	150,7	21,2	100,2			365
	Light breeds	21,4	10,5	125,1	19,2	74,9			365
	2.B								

Figure 2.A Location of the groups of animals, **2.B** Information needed for “Tier 2” calculation at ex-animal level

1.1.3 Calculation method “Tier 3”

The “Tier 3” calculation of manure quantity and N, P, K content per animal species and age groups at ex-animal level is based on the regional data of animal production and feeding. It is recommended to use official region-based information. When the animal group is divided into subgroups on the basis of some parameter, the number of subgroups can be maximum 10.

The names and the locations of subgroups in the table (column C, white fields) are not fixed (Figure 3.A). Information needed for “Tier 3” calculation is described in the white fields, columns D – O and light grey fields AA - AC (Figure 3.B). All groups and information added to the tables are available in the calculations. The example values are based on the grouping of dairy cows used in Denmark and their corresponding average feeding values. If animals are not grazing (there is no access to pasture and outdoor areas), the corresponding fields, columns AA (days per year) and AB (hours per day) stay empty. Fields in the column AC “Rearing period” (days/year) must always be filled. As the calculations are characterized by the production of manure per year, ‘365’ days should be used for animals with a rearing period of more than one year, and a feasible amount of days for animals with a shorter rearing period than one year.

Cattle	Animal category	Tier 3								Tier 2,3			
		Milk		Body weight gain		Feeding					Grazing		Rearing
		Yield	Protein			DM		DM digestibility	CP	P	K	days/	hours/
		kg/year	%	kg	kg/year	kg/animal/year	%	g/kg DM			year	day	days/
Cows	Slurry (Tier1)												
	Solid (Tier1)												
	Heavy breeds	10410	3,44			7851	71	166	4,04	15,0			365
	Light breeds	7300	4,16			6466	71	168	4,23	13,5			365
		3.A	3.B										

Figure 3.A Location of the groups of animals, **3.B** Information needed for “Tier 3” calculation at ex-animal level

The annual amount of manure (ex-animal) is calculated from the following formulas (DM = dry matter):

Manure (ex-animal), kg/year = Faeces (ex-animal), kg/year + Urine (ex-animal), kg/year;

Faeces (ex-animal), kg/year = Feed DM, kg/year x (1 - DM digestibility, %/100) / Faeces DM, %;

Urine (ex-animal), kg/year = Faeces (ex-animal), kg/year / k, where the k is constant (Sheet “DB additional information”; table “Default values: manure DM, %; column M)

The annual amount of manure (ex-animal) **nitrogen, phosphorus and potassium** content is calculated from the following formula:

Manure N, P, K kg/year = Feed N, P, K, kg/year – (Milk N, P, K, kg/year + Retention N, P, K, kg/year + Foetus N,P,K, kg/year + Eggs N, P, K kg/year)

The average content of nitrogen, phosphorus and potassium for milk, retention, foetus and eggs is given in the table “Default values: gain, foetus, milk, eggs”; Sheet “DB additional information”; columns B – F.

1.2 Technologies (Sheet “DB technologies”)

1.2.1 Calculation method “Tier 1”

The “Tier 1” calculation is based on the manure types and methods listed in the EMEP/EEA air pollutant emission inventory Guidebook (2016). The locations and the names of the manure types in the database (table), column C, are fixed and not editable (Figure 4.A). The table shows parameters describing manure quantity and properties at ex-storage level as well as the total amount of nitrogen loss (ammonia emission) from housing, storage and yards (kg/year); nitrogen loss (ammonia emission) connected with grazing (kg/year) and nitrogen loss (nitrogen dioxide) from all manure management chain (kg/year), columns D – L. Calculations at ex-housing level for “Tier 1” method is not available (Figure 4.B).

Animal species and categories	Tier 1								
	Manure type	Quantity	DM	N	P	K	N-loss		
							From housing, storage and yards	From grazed pastures	NO ₂
		After storing period					NH ₃		
		t animal/year	%	kg/animal/year		kg/year			
Dairy cows	Slurry (Tier1)	20,6	5,9	105	25	112	19,2		0,011
	Solid (Tier1)	18,2	20,3	115	30	130	16,9	2,9	0,236
	4.A	4.B							

Figure 4.A Location of the manure types, **4.B** Information needed for “Tier 1” calculation at ex-storage level

1.2.2 Calculation method “Tier 2 and Tier 3”

1.2.2.1 Ex-housing

All calculation of manure quantity, N, P, K content and losses by animal species and age groups at ex-housing level based on mass balance method. It is recommended to use official region-based information. The names and the locations of keeping technologies in the table (column N, white fields) are not fixed (Figure 5.A). When complete information on keeping technologies used in the region (the Tier 3 method) is available then data can be entered separately for each keeping technology (Figure 5.A.1), if only more general information (“Tier 2” method) is available then it can also be used (Figure 5.A.2). Information needed for “Tier 2 and 3” calculation is described in the white fields, columns O – Y (Figure 5.B). All technologies and information added to the tables are available in the calculations.

Keeping technology, manure removal system	Additional nutrient sources		
	Bedding	Feed residues	Technological water
	kg/animal/day		t/animal/year
Tie-up housing system (manure removal with scraper)	8,0	0,1	0,5
Tie-up housing system, grates	0,0	0,1	2,0
Cubicles with solid floor	0,0	0,1	2,0
Cubicles with slatted floor (manure channel, continuous removal)	0,0	0,1	2,0
Deep litter (whole area)	10,0	0,2	0,1
Deep litter with long feeding area and solid floor	8,0	0,2	0,1
Deep litter with long feeding area and fast drying floor (scraper and urine drainage)	8,0	0,2	0,1
Solid manure (loose housing)	10,0	0,1	0,5
5.A.1			
Slurry	0,0	0,1	2,0
Solid	8,0	0,1	0,5
Deep litter	12,0	0,1	0,1
5.A.2	5.B.1	5.B.2	5.B.3

Figure 5.A.1 and 5.A.2 Location of keeping technology or manure type, **5.B** Information needed for “Tier 2” and “Tier 3” calculations at ex-housing level

Column O “Bedding” (figure 5.B.1) – Amount of bedding per keeping technology or manure type (kg/animal/day).

Column P “Feed residues” (figure 5.B.2) – Amount of feed residues (feed that can get into manure in the animal house) per keeping technology or manure type (kg/animal/day). If information is not available, the cell stays empty.

Column Q “Technological water” (figure 5.B.3) – Only includes water (washing water for equipment, drinking water spillages etc.) that is removed with manure to the manure storage. It is counted separately according to keeping technology or manure type (tonnes/animal/year).

N-loss			Water evaporation	DM-loss	Manure type(s)		
NH ₃ -N	N ₂ O-N	Denitrification			Code	Partitioning of N, P, K	
%						Liquid	Solid
10,00					1		
6,00					2		
20,00					2		
12,00					2		
13,20	1,00	5,00	40,0	40,0	3		
15,90	1,00	5,00	40,0	40,0	4	40	60
11,10	1,00	5,00	40,0	40,0	4	40	60
10,00					5		
20,00					2		
10,00					1		
7,50	1,00	5,00			3		
5.B.4	5.B.5	5.B.6	5.B.7	5.B.8	5.B.9	5.B.10	5.B.11

Figure 5.B (continuation). Information needed for “Tier 2” and “Tier 3” calculations at ex-housing level

Column R “NH₃-N” (figure 5.B.4) – loss of ammonia nitrogen (emission factor) from animal house depending on the keeping technology or manure type (%). Loss of ammonia nitrogen at ex-housing level is calculated on the basis of TAN in the ex-animal manure.

Column S “N₂O-N” (figure 5.B.5) – loss of nitrogen as laughing gas (emission factor) from animal house depending on the keeping technology or manure type (%). Factor is needed only for keeping technologies producing deep litter.

Definition of the deep litter manure – Faeces or droppings and urine mixed with large amounts of bedding (e.g. straw, sawdust and wood shavings) and accumulated over a certain time on the floors of buildings housing any type of livestock or poultry.

Column T “Denitrification” (figure 5.B.6) – loss of nitrogen as N₂ (emission factor) from animal house depending on the keeping technology or manure type (%). Factor is needed only for keeping technologies producing deep litter.

Columns U and V “Water evaporation” and “DM loss” (figures 5.B.7 and 5.B.8) – reduction in manure volume in the animal house due to moisture evaporation and dry matter decomposition (%). Factor is needed only for keeping technologies producing deep litter. Reduction depends on the animal species and bedding type.

Column W “Code” (figure 5.B.9) – manure type(s) code. Field has to always be filled. Manure type(s) depend on the keeping technology of animals. The list of manure types and corresponding codes are given in the table 1.

Table 1. Manure types and codes

Manure types	Code	Example of keeping technology
Liquid manure (urine) + solid manure	1	Tie-up housing system (manure removal with scraper) for cattle; keeping of fattening in the pens with solid floor.
Liquid manure	2	Cubicles with solid floor for cattle; keeping of fattening pigs in the pens with partially slatted floor (50-75%).
Deep litter	3	Deep litter (whole area) for cattle and pigs; floor keeping of laying hens.
Liquid manure (urine) + solid manure	4	Deep litter with long feeding area and solid floor for cattle; deep litter (separate lying area) for fattening pigs. Liquid manure from the feeding area is removed daily.
Solid manure	5	Solid manure (loose housing) for cattle and pigs. Bedding quantity is high; manure is removed daily or weekly.

Columns X and Y “Partitioning of N, P, K” (figures 5.B.10: solid and 5.B.11: liquid) – these are needed only for specific keeping technologies where deep litter manure is formed in the lying area (removed few times per year or after the batch has been finished) and liquid manure is produced in the feeding area (removed daily or weekly). Manure type code is 4.

1.2.2.2 Ex-storage

All calculation of manure quantity, N, P, K content and losses by manure types at ex-storage level are based on the mass balance method. It is recommended to use official region-based information (emission factors, weather data, etc.). Manure at ex-storage level is divided per animal species to four categories: manure from (1) cattle, sheep, goats, horses, other livestock, (2) pigs, (3) poultry, and (4) fur animals. The names and the locations of manure storage covering methods in the table (column AC, white fields) are not fixed (Figure 6.A). Information needed for “Tier 2 and 3” calculation is described in the white fields, columns AD – AR (Figure 6.B). All technologies and information added to the tables are available in the calculations.

Animal category	Manure type	Storing technology	Losses			
			NH ₃ -N	N ₂ O-N	Denitrification	DM
			%			
Cattle, sheep, goats, horses, other livestock	Slurry	Storage roofed	3,4	0,1		1,0
		Storage, natural cover	4,0	0,1		1,0
		Storage, floating cover	3,8	0,1		1,0
	Solid	Storage roofed	5,0	2,0	5,0	5,0
		Storage, natural cover	7,0	2,0	5,0	5,0
		Heap, natural crust	7,0	2,0	5,0	5,0
	Deep litter	Storage roofed	5,0	1,0	5,0	15,0
		Storage, natural cover	7,0	1,0	5,0	15,0
		Heap, natural crust	7,0	1,0	5,0	15,0
		6.A	6.B.1	6.B.2	6.B.3	6.B.4

Figure 6.A Location of the manure storage covering methods, **6.B** Information needed for “Tier 2” and “Tier 3” calculations at ex-storage level

Column AD “NH₃-N” (figure 6.B.1) – loss of ammonia nitrogen (emission factor) from a manure storage or heap depending on the covering method (%).

Column AE “N₂O-N” (figure 6.B.2) – loss of nitrogen as laughing gas (emission factor) from a manure storage or heap depending on the manure type (%).

Column AF “Denitrification” (figure 6.B.3) – loss of nitrogen as N₂ (emission factor) from a manure storage or heap depending on the animal species and manure type (%). Factor is needed mainly for solid or deep litter manure.

Column AG “DM” (figure 6.B.4) – dry matter decomposition (%) in a manure storage or heap depending on the manure type.

Water precipitation and evaporation						Leaching			Proportion of manure directly applied on field
Storage volume	Height of the storage	Manure per year (average fulfillment)	Net precipitation	Net evaporation	Manure volume weight	N	P	K	
m ³	m	m ³	mm		kg/m ³	%			
3333,0	3,00	3000,0	0,0	100,0					
3333,0	3,00	3000,0	600,0	300,0					
3600,0	3,00	3000,0	600,0	100,0					
	1,75	3000,0	0,0	100,0	750,0				
	1,75	3000,0	600,0	300,0	750,0				
	1,75	3000,0	600,0	300,0	750,0	1,0	1,0	5,0	
6.B.5	1,75	3000,0	0,0	100,0	500,0				0 6.B.14
	1,75	3000,0	600,0	300,0	500,0				
	1,75	3000,0	600,0	300,0	500,0	1,0	1,0	5,0	
	6.B.6	6.B.7	6.B.8	6.B.9	6.B.10	6.B.11	6.B.12	6.B.13	

Figure 6.B (continuation). Information needed for “Tier 2” and “Tier 3” calculations at ex-storage level

Column AH “Storage volume” (figure 6.B.5) – maximum volume of manure storage (m³) depending on the covering method. Needed only for liquid (semi-solid) manure storages (average based on regional information available).

Column AI “Height of the storage” (figure 6.B.6) – average wall height (m) of liquid manure storages or height of manure layer (m) in the solid manure storages or heaps (based on regional information available).

Column AJ “Manure per year (average fulfillment)” (figure 6.B.7) – average manure volume in the manure storages depending on the manure type and covering method (based on regional information available).

Column AK “Net precipitation” (figure 6.B.8) – average regional precipitation (mm) depending on the covering method. For storages with permanent roof, it is zero.

Column AL “Net evaporation” (figure 6.B.9) – average regional evaporation (mm) depending on the covering method. For open (covered with natural crust) storages usually with 50% of evaporation is assumed. It depends strictly from average temperature of the year. From storages with permanent roof or floating cover, the evaporation is much less (10-30%).

Column AM “Manure volume weight” (figure 6.B.10) – solid or deep litter manure volume weight (kg/m³). Not needed for liquid manure.

Column AO “N” (figure 6.B.11) – nitrogen loss (leaching factor, %). Only needed if solid or deep litter manure is stored in a field heap.

Column AP “P” (figure 6.B.12) – phosphorus loss (leaching factor, %). Only needed if solid or deep litter manure is stored in a field heap.

Column AQ “K” (figure 6.B.13) – potassium loss (leaching factor, %). Only needed if solid or deep litter manure is stored in a field heap.

Column AR “Proportion of manure directly applied on field” (figure 6.B.14) – Only needed if deep litter manure is spread directly from animal house to field without storing (%). Not available for liquid or solid manure types.

Column AT “NH₃-N” (figure 7.A) – loss of ammonia nitrogen (emission factor) during grazing.

Column AU “N₂O-N” (figure 7.B) – loss of nitrogen as laughing gas (emission factor) during grazing.

Tier 2, Tier 3 Grazing	
Losses	
NH ₃ -N	N ₂ O-N
7.A	7.B
1,0	0,1

Figure 7.A and 7.B Information needed for “Tier 2 and Tier 3” calculations to calculate nitrogen losses during grazing

1.3 Additional information (DB additional information)

The database contains all coefficients needed for “Tier 2” and “Tier 3” calculations. If region-specific coefficients are available, it can be applied as all data in the tables are editable.

Table “Default values: gain, foetus, milk, eggs” (columns B – F). The table contains the following: the efficiency of nitrogen, phosphorus and potassium use for production of milk, body gain and eggs, retention in the animal body and digestibility in the animal organism of these elements per animal species and age group (column F). The coefficients in the table are required for “Tier 3” calculations of nitrogen, phosphorus and potassium quantity in the manure at ex-animal level.

Table “Default values: manure DM, %, urine level and proportion %” (columns H – P). The table contains the average dry matter (DM) content in the faeces (column K) and urine (column L) and coefficient k (urine level, column M) required for “Tier 3” calculations of manure quantity at ex-animal level by animal species and age groups. The formula for calculating the amount of urine is described in the chapter 1.1.3 “Calculation method Tier 3”. The coefficients in the column N – P are

needed for calculation if “Tier 2” method is used. In that case, the quantity, nitrogen, phosphorus and potassium content of manure at ex-animal level are based on nationally/internationally available default values. Total ammonia nitrogen (TAN) proportion in the manure (column N), proportion of total phosphorus in the urine (column O) and proportion of potassium in the urine (column P) are given.

Table “Additional nutrient sources” (columns R – V). The table contains a list of materials, which can be added to the manure in the animal houses (bedding, feed residues etc.) and their average nitrogen, phosphorus and potassium content. All information in the table is editable if regional data are available. The coefficients is needed for “Tier 2” and “Tier 3” calculations at ex-housing level.

2 Calculations

2.1 Ex-animal (sheet “Calc ex-animal”)

2.1.1 Calculation method “Tier 1”

The animal group (and manure type) for calculation is selected from drop-down menu (column D). If “Tier 1” calculation method is available for a specific animal category, it is marked with phrase “tier 1” (in the parentheses) in the list (Figure 8.A). The “Tier 1” animal categories (calculations) must always be placed in the top row(s) of the table for a specific animal group (Figure 8).

The number of animals in a specific group is entered to the fields in column E “Animal number” (Figure 8.B). The number of calculation method for a specific group of animals is entered to the fields in column F “Calculation method” (Figure 8.C). For “Tier 1” the number of calculation method is “1”.

Animal category			Animal number	Calculation method
Cattle	Dairy cows	Slurry (Tier1)	100	1
		Slurry (Tier1)	100	1
		Solid (Tier1)		
		Heavy breeds		
		Light breeds		
	Cow and bull calves			
	Heifers			
		8.A	8.B	8.C

Figure 8.A Selection of animal categories, **8.B** Animal number in the specific animal group and **8.C** Selection of calculation method

All ex-animal level calculations are made automatically (columns I – Y). Total amount of manure, dry matter percentage and nitrogen, phosphorus and potassium content are calculated. If some specific animal group is grazing, the amount of manure and nitrogen, phosphorus and potassium remaining on the pasture are also calculated (Figure 9).

Manure (ex-animal)					Manure from grazing/outdoor period			
Quantity	DM	N	P	K	Quantity	N	P	K
t/year	%	Total			t/year	t/year		
		t/year						
2290,0	15,3	13,4	3,0	10,1	0,0	0,0	0,0	0,0
2290,0	15,3	13,4	3,0	10,1	380,0	2,2	0,5	1,7

Figure 9. Parameters calculated at ex-animal level

2.1.2 Calculation methods “Tier 2” and “Tier 3”

The animal groups (subgroups) for calculation are selected from a drop-down menu (column D). All animal groups added to the database “DB animal categories” are available for calculation. The placing and order of animal groups in the table is not fixed when using “Tier 2” or “Tier 3” calculation (Figure 10.A). The number of animals in a specific group is entered to the fields in column E “Animal number” (Figure 8.B). The number of calculation method for a specific group of animals is entered to the fields in column F “Calculation method” (Figure 8.C). For “Tier 2” the number of calculation method is “2” and for “Tier 3” – “3”. All ex-animal level calculations are made automatically (columns I – Y). Total amount of manure, dry matter percentage and nitrogen, phosphorus and potassium content are calculated. If some specific animal group is grazing, then also the amount of manure and nitrogen, phosphorus and potassium remaining on the pasture are calculated (Figure 11). If calculation method “Tier 2” is selected, then ex-animal manure amount and properties are calculated on the basis of information added in the “Tier 2” section (average values) of the database “DB animal categories”. If calculation method “Tier 3” is selected, then ex-animal manure amount and properties are calculated based on information added in the “Tier 3” section (data about feeding) of the database “DB animal categories”.

Dairy cows	Light breeds	100	3
	Heavy breeds	100	2
	10.A		

Figure 10.A Placing and order of animal groups in the table if calculation method “Tier 2” or “Tier 3” is used.

Manure (ex-animal)					Manure from grazing/outdoor period			
Quantity	DM	N	P	K	Quantity	N	P	K
t/year	%	Total			t/year	t/year		
		t/year						
2139,8	10,5	12,4	2,0	7,5	0,0	0,0	0,0	0,0
2600,0	10,5	15,1	2,1	10,0	0,0	0,0	0,0	0,0

Figure 11. Parameters calculated at ex-animal level

If the keeping technologies of animals are known on a more general level (“Tier 2”), for example on the basis of manure type, the choice of technology can also be made from the drop-down menu, column D (Figure 14.A). All technologies added to the database (sheet “DB technologies” column N) of the specific animal group are available.

Heavy breeds	Cubicles with solid floor	25
	Deep litter (whole area)	25
	Cubicles with solid floor	50
	Total	100
Light breeds	Slurry	60
	Solid	15
	Deep litter	25
		100
0	Slurry	
	Solid	
	Deep litter	
	14.A Total	0

Figure 14.A Choice of keeping technology ("Tier" 2)

There is an exception with the animal category "Sows", columns B – AH; rows 160 – 214. The difference is due to the fact that sows are often kept in buildings with different technology during the reproduction cycle. It is especially important if the keeping technologies producing different manure types (for example liquid vs. solid) are used. If this specific information is available ("Tier" 3), the choice of keeping technologies is possible across the phases of the reproductive cycle (Figure 14.B). Technologies used in the free and gestation period are in the upper half of the field and the technologies used in the lactation period in the lower half. The length of the corresponding period; free and gestating period, column AG, and lactating period, column AH (percentage of the total reproductive cycle), must also be entered (Figure 14.C). If specific information is not available ("Tier 2"), a more general method is used (Figure 14.A). In that case, the choice of keeping technology is always made in the first (top) row of the field (the second row stay empty) and the length of period is 100% (Figure 16.C). '100' is entered to the cells in column AG, while the cells in column AH stay empty.

		Free and gestating period	Lactating period
		%	
Sows1	Individual housing (partially slatted floor)	70	30
	Loose housing (deep litter)		
	Individual housing (fully slatted floor)	70	30
	Loose housing (deep litter)		
14.B		14.C	

Figure 14.B Choice of keeping technologies for sows, **14.C** Length of different phases of the reproductive cycle (percentage of total cycle)

To the cells in column E (Figure 15.A), the number of animals kept with this technology is entered. The percentage of animals kept with specific technology is calculated automatically, column F (Figure 15.B).

Heavy breeds	Cubicles with solid floor	25	25,00
	Deep litter (whole area)	25	25,00
	Cubicles with solid floor	50	50,00
	15.C Total	100	100,00
Light breeds	Slurry	60	60,00
	Solid	15	15,00
	Deep litter	25	25,00
	15.A Total	100	100,00

Figure 15.A Entering animal number, **15.B** Percentage of animals kept with specific keeping technology

The rows “Total” (Figure 15.C) automatically calculate the number of animals in this group. The number must be equal to the number entered to the fields in sheet “Calc ex-animal” column E. All ex-housing level calculations are made automatically (columns G – AE). Total amount of manure, dry matter percentage and nitrogen, phosphorus and potassium content and losses of nitrogen from animal houses are calculated (Figure 16). Calculations are based on the specific information for every keeping technology added to the database “DB technologies”, columns O – Y.

Manure (ex-housing)					N-loss		
Quantity	DM	N	P	K	NH ₃ -N	N ₂ O	Denitrification
t/year	%	t/year					
700,9	9,8	3,363	0,532	2,512	0,452	0,000	0,000
447,3	19,7	3,726	0,589	3,683	0,298	0,038	0,188
1401,8	9,8	6,726	1,065	5,025	0,904	0,000	0,000
2550,1	11,6	13,814	2,186	11,221	1,655	0,038	0,188
1406,1	9,7	6,816	1,197	4,547	0,766	0,000	0,000
372,8	19,1	1,986	0,325	1,695	0,096	0,000	0,000
647,9	23,1	3,318	0,564	3,291	0,120	0,031	0,156
2426,7	14,7	12,120	2,086	9,533	0,982	0,031	0,156

Figure 16. Parameters calculated at ex-animal level

2.3 Ex-storage (sheet “Calc ex-housing, ex-storage)

2.3.1 Calculation method “Tier 1”

Because manure is divided only to liquid and solid manure in the tier 1 method, a more detailed specification in the table (columns AG – BT) is not available. Results for “Tier 1” calculations at ex-storage level are automatically available in the sheet “Report (Tier 1)”.

2.3.2 Calculation method “Tier 2” and “Tier 3”

If “Tier 2” or “Tier 3” method is used, the shares of manure per animal species and manure type is automatically done according to the choices of keeping technology at the ex-housing level. The table (columns AG – BT) summarizes the amounts of manure and of nutrients and losses per

different age groups of the animal species. If the percentages of different storage cover types per volume of manure (per manure types) are known, the selection of the respective cover type is made from the drop-down menu, column BG (Figure 17.A). The percentage of manure with the corresponding type of cover is entered in the cells of column BH (Figure 17.B). All calculations at ex-storage level are made automatically according to the information entered to the database, sheet “DB technologies”, table “Tier 2, Tier 3 Ex-storage”, columns AA – AR.

Animal category	Manure type	Cover type	Percentage
Cattle	Slurry	Storage roofed	50,00
		Storage, natural cover	25,00
		Storage, floating cover	25,00
		Total	100,00
	Solid	Storage roofed	
		Storage, natural cover	
		Heap, natural crust	
		Total	0,00
	Deep litter	Storage, natural cover	50,00
		17.A	17.B
		Heap, natural crust	50,00
		Total	100,00

Figure 17.A Choice of covering type (“Tier” 2 and “Tier” 3), **17.B** Entering of percentage of manure covered with specific cover

Manure amount and nitrogen, phosphorus, potassium quantity and losses by manure type and covering method are calculated at ex-storage level, columns BI-BT (Figure 18.A). For storage methods where nutrient leaching is possible (solid or deep litter manure in field heaps) also losses via leaching are calculated, columns BR-BT (Figure 18.B). The rows “Total” gives the totals for this type of manure (Figure 18.C).

Manure type	Cover type	Percentage	Manure (ex-storage) Tier 2,3					N-loss			Leaching		
			Quantity	DM	N	P	K	NH ₃ -N	N ₂ O	Denitrification	N	P	K
			t/year	%									
Slurry	Storage roofed	50,00	1641,7	10,09	8,455	1,352	5,946	0,298	0,009	0,000	18.B		
	Storage, natural cover	25,00	947,3	8,74	4,201	0,676	2,973	0,175	0,004	0,000			
	Storage, floating cover	25,00	1023,1	8,09	4,210	0,676	2,973	0,166	0,004	0,000			
	18.C Total	100,00	3612,1	9,2	16,865	2,704	11,892	0,640	0,018	0,000			

Figure 18. Parameters calculated at ex-storage level

3 Reports

3.1 Calculation method “Tier 1”

The report sheet, “Report “Tier 1”” gives manure properties at ex-animal and ex-storage level; additionally total nitrogen loss (all stages of the production cycle) as ammonia and nitrogen dioxide (Figure 19). The “Tier 1” calculation is based on the animal categories and methods listed in the EMEP/EEA air pollutant emission inventory Guidebook (2016).

Animal category	Manure type	Manure (ex-animal) Tier 1					Manure (ex-storage) Tier 1					N-loss	
		Quantity	DM	N	P	K	Quantity	DM	N	P	K	NH ₃ -N	NO ₂
		t/year	%	t/year	t/year	t/year	t/year	%	t/year	t/year	t/year		
Cattle	Slurry (Tier1)	2290,0	15,3	13,400	3,010	10,100	2060,0	5,9	10,500	2,500	11,200	1,920	0,001
	Solid (Tier1)	2290,0	15,3	13,400	3,010	10,100	1820,0	20,3	11,500	3,000	13,000	1,690	0,024

Figure 19. Parameters given in the report if “Tier 1” calculation method is used

3.2 Calculation method “Tier 2” and “Tier 3”

The report sheet “Report “Tier 2 and 3”” gives manure properties at ex-animal, ex-housing and ex-storage level (Figure 20.A). The amount of manure nitrogen, phosphorus and potassium remaining in the pasture when the animals are grazed (Figure 20.B), nitrogen emission (all stages of the production cycle separately) as ammonia, dinitrogen oxide and via denitrification (Figure 21.A) and manure nutrient leaching (Figure 21.B) are given. The values in the table are summarized by animal species.

Animal category	Manure											
	Ex-animal				Ex-housing				Ex-storage			
	Quantity	N	P	K	Quantity	N	P	K	Quantity	N	P	K
	t	kg	kg	kg	t	kg	kg	kg	t	kg	kg	kg
Cattle	4738	27513	4109	17648	4527	12,5	26954	4287	20985	5073	10,4	24930
Pigs	0	0	0	0	0	0,0	0	0	20.A	0	0,0	0

Figure 20.A Manure parameters given in the report at ex-animal, ex-housing and ex-storage level if “Tier 2” and “Tier 3” calculation method is used

Animal category	Grazing/Outdoor		
	N	P	K
	kg		
Cattle	0	0	0
Pigs	0	20.B	0

Figure 20.B Manure parameters given in the “Tier 2” and “Tier 3” report if animals are grazed

Losses										
Ex-housing			Ex-storage			Grazing		Leaching		
NH ₃ -N	N ₂ O-N	Denitrification	NH ₃ -N	N ₂ O-N	Denitrification	NH ₃ -N	N ₂ O-N	N	P	K
kg										
1603	92	462	1300	206	472	0	0	47	8	227
0	0	0	0	21.A	0	0	0	0	21.B	0

Figure 21.A Nitrogen emission at different stages of the production cycle; **21.B** manure nutrients losses via leaching

4 Comparison of the results obtained with existing systems and the new calculation tool

The “Tier 1” calculation is based entirely on the coefficients (table values) entered in the database (conforms to the IPCC 2006 methodology) and the results obtained with new tool match to the existing system.

The “Tier 2” calculation is based on the coefficients (table values) at ex-animal level, while the ex-housing and ex-storage levels are calculated with the mass balance method. The “Tier 3” calculates also ex-animal level and thus is a total mass balance method. Because the “Tier 3” method is more accurate, but also more complex, only the “Tier 3” calculation is included in the comparison.

Annual regional level average data on production, feeding, housing and manure management technology of dairy cows were used in the calculation (“Tier 3” method). The Finnish Normative Manure System (FNMS) was used for comparison (Luostarinen et al. 2017). In both cases, the input data were the same. The results are shown in Table 2. According to this test, the currently instructed and introduced system works well at least for dairy cows. Additional testing with other animals can be done per country using their own national input data. The testing serves as the means to also implement the system in new countries without such tools for manure data generation.

Table 2. Comparison of the results obtained with FNMS system and the currently instructed regional level calculation tool

Parameter and unit		Regional tool	FNMS
Number of dairy cows	heads	274954	
Ex-animal			
Nitrogen	Total/t/year	34 846	35 634
Phosphorus		5 418	5 802
Nitrogen	Per animal/kg/year	126.7	129.6
Phosphorus		19.7	21.1
Ex-housing			
Liquid manure	Total/t/year	4 688 600	4 796 600
	Per animal/t/year	23.68	24.23
	N total/kg/t	4.91	4.94
	P kg/t	0.84	0.87
	K kg/t	4.73	4.61
	NH ₃ -N emission/t/year	2445.6	2040.6
Solid manure	Total/t/year	1 988 900	2 026 200
	Per animal/t/year	25.83	26.32
	N total/kg/t	5.34	5.38
	P kg/t	0.85	0.88
	K kg/t	6.14	6.53
	NH ₃ -N emission/t/year	475.5	570.2
Ex-storage			
Liquid manure	Total/t/year	5 073 000	5 188 100
	Per animal/t/year	25.63	26.21
	N total/kg/t	4.36	4.32
	P kg/t	0.77	0.81
	K kg/t	4.37	4.26
	NH ₃ -N emission/t/year	888.1	1124.8
Solid manure	Total/t/year	2 119 600	2 227 400
	Per animal/t/year	27.53	28.93
	N total/kg/t	4.35	4.19
	P kg/t	0.80	0.80
	K kg/t	5.72	5.94
	NH ₃ -N emission/t/year	637.3	569.0

References

Luostarinen, Sari; Grönroos, Juha; Hellstedt, Maarit; Nousiainen, Jouni; Munther, Joonas. 2017. SUOMEN NORMILANTA – laskentajärjestelmän kuvaus ja ensimmäiset tulokset. *Luonnonvara- ja biotalouden tutkimus* 47/2017. Available online: <http://urn.fi/URN:ISBN:978-952-326-441-0>.



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