INSTRUCTIONS FOR MANURE PROPERTIES CALCULATION TOOL

Manual

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Interreg Baltic Sea Region

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Preface

The calculation tool allows mass balance calculation of the annual manure production of cattle, pigs and poultry (laying hens , broilers and young birds) and the chemical composition at ex-animal, ex-housing and ex-storage levels. Algorithms used at ex-animal level are derived from the Danish system (DIAS report no 7).

Legend

The meaning of colors in the tables:

Yellow fields – automatically calculated values;

Green fields – changing values (input data);

Grey fields – calculated total values;

White fields – mainly hidden columns with intermediate calculations and formulas, except for the database (the sheets “Technology” and “Additional information”);

Red numbers – total values (per animal or per herd).

Only green and white (database) fields are open for the user, all other fields are closed (protected with password).

The tool “Calculation tool for manure properties at farm level” is designed to calculate manure quantity and chemical composition in one specific animal building or buildings from where manure is collected to the same manure storage(s).

Within one file, it is possible to calculate simultaneously the amount and composition of manure from one cattle, pig and poultry farm. At ex-housing and ex-storage level only one animal species is open at a time, all other options are automatically locked.

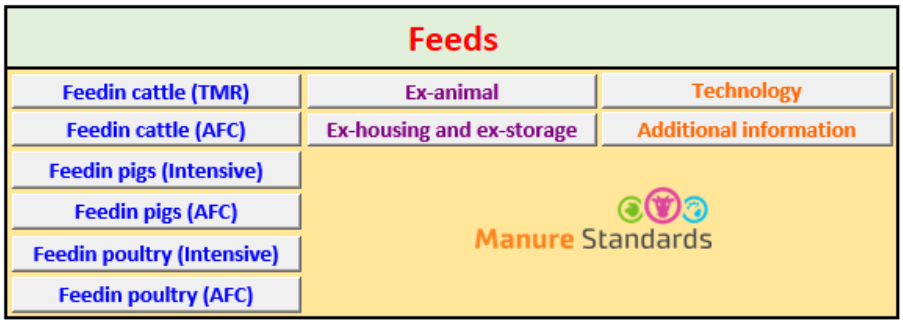


Figure 1. A button system for navigation

A button system has been created for more convenient navigation between pages (figure 1).

1. EX-ANIMAL

All calculations in the sheet “Ex-animal” are done automatically. Adding and modifying data is not allowed on this sheet.

The annual amount of manure (for ex-animal) is calculated from the following formulas:

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 (table 1)

Table 1. *Constant k for calculation of annual urine amount*

Animal group	Constant k	Faeces DM, %	Urine DM, %
Dairy cows	1,85	13,5	5,0
Cow calves (age 0-6 months)	1,50	17,0	4,0
Bull calves (age 0-6 months)	1,50	17,0	4,0
Heifers (age 6 months to calving)	2,00	20,0	5,0
Beef cattle (age 6 months to slaughtering)	2,00	20,0	5,0
Suckler cows	2,00	13,5	5,0
Slaughter pigs	0,324	25,2	2,2
Sows	0,324	25,0	2,2
Weaners	0,324	25,2	2,2
Chicken broilers		25,0	
Laying hens		25,0	
Young birds		25,0	

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)

Table 2 gives nitrogen, phosphorus and potassium average content for milk, retention, foetus and eggs.

Table 2. *N, P, K content in milk, retention, foetus, and eggs*

Animal group	Parameter	Milk g/kg	Retention g/kg gain	Foetus g/kg	Eggs g/kg
Dairy cows	N	Protein/6,38	25,6	29,6	
	P	0,96	6,1	10,2	
	K	1,60	1,8	2,1	
Cow calves (age 0-6 months) Bull calves (age 0-6 months) Beef cattle (age from 6 months to slaughtering)	N		25,6		
	P		6,1		
	K		1,8		
Heifers (age from 6 months to calving)	N		25,6	29,6	
	P		6,1	10,2	

	K		1,8	2,1	
Suckler cows	N		25,6	29,6	
	P		6,1	10,2	
	K		1,8	2,1	
Slaughter pigs Weaners Sows	N		29,6		
	P		5,5		
	K		2,2		
Laying hens	N		29,0		18,1
	P		3,3		2,1
	K		2,5		1,3
Broilers Young birds	N		29,0		
	P		3,3		
	K		2,5		

1.1 Entering production and feeding data

Data entry is possible in two ways. It depends on the availability and accuracy of the input information (especially feeding data). For large farms, where all information is well documented, we designed solution that is based on daily feed rations (for all existing animal categories). The second option is more general solution, which is based on annual feed consumption.

These options are available for all animal species in the navigation window: For cattle – buttons “Feedin cattle (TMR)” and “Feedin cattle (AFC)”; for pigs buttons “Feedin pigs (Intensive)” and “Feedin pigs (AFC)” and for poultry “Feedin poultry (Intensive)” and Feedin poultry (AFC)” respectively. In each particular case, the choice between options depends on the availability and accuracy of the input data. It also depends on the animal grazing. In the first case, “Feedin cattle (TMR)”, “Feedin pigs (Intensive)”, “Feedin poultry (Intensive)” is taken into account that animals are kept in the barn throughout the year. In the second case, all “AFC” options, it is also possible to add grazing (or access to outside area) to the calculations.

For cattle (all age and production groups), the calculation is based on dry matter (DM), crude protein (CP), phosphorus (P), potassium (K) intake and dry matter digestibility. In the case of pigs and poultry, the amount of feed is also taken into account. The following data units are for daily feed rations (per one animal):

1) Cattle: DM kg/day; CP, P, K g/day; DM digestibility %;
2) Pigs and poultry: Feed, DM, CP, P, K g/day; DM digestibility %.

The following data units are for annual feed consumption, and are similar for all animal species (per herd): DM; CP, P, K t/year; DM digestibility %, for pigs and poultry also feed quantity t/year.

Usually the units used in the chemical analysis and in the feed tables are not compliant with the units listed above. For example, see table 3.

Table 3. *Units used in the feed tables and chemical analysis (can vary per country)*

Feed	DM	Organic matter (OM) digestibility	Crude ash	CP	P	K
	%	%	% DM	% DM	g/kg DM	g/kg DM
Barley	86,0	83,0	2,5	12,5	4,1	5,5
Grass silage (50% legumes)	35,0	71,0	9,3	15,8	3,1	23,0

Formulas for recalculation the feed data, so that it would be usable in the calculation tool, are (per one kilogram of feed):

DM, kg: Feed quantity (kg) x DM (%)/100. Barley: 1 x 86/100 = 0,86 kg; grass silage: 1 x 35/100 = 0,35 kg

DM digestibility, %: (Digestibility of OM (%) x OM in fresh matter (%)/ DM (%) + digestibility of ash (%) x ash in fresh matter (%))/ dry matter (%). Digestibility of ash is assumed to be 40%. Barley: (((1000*86/100-1000*2,5/100)*83/100)+1000*2,5/100*40/100)/(1000*86/100)*100 = 81,75%; grass silage: (((1000*35/100-1000*9,3/100)*71/100)+1000*9,3/100*40/100)/(1000*35/100)*100 = 62,76%;

CP, g: Feed quantity (kg) x DM (%)/100 x CP (% DM)/100. Barley 1 x 86/100 x 12,5/100 = 0,1075 kg = 107,5 g; grass silage: 1 x 35/100 x 15,8/100 = 0,0553 kg = 55,3 g

P, g: Feed quantity (kg) x DM (%)/100 x P g/kg DM. Barley 1 x 86/100 x 4,1 = 3,526 g; grass silage 1 x 35/100 x 3,1 = 1,085 g

K, g: Feed quantity (kg) x DM (%)/100 x K g/kg DM. Barley 1 x 86/100 x 5,5 = 4,73 g; grass silage 1 x 35/100 x 23 = 8,05 g

1.1.1 Sheet “Feeds”

The page is intended to simplify the input of feed data. If necessary, the entered data will automatically be calculated in the correct form. Possible input data units are shown in Table 4.

Feed	Dry matter		Digestibility		Ash				Crude protein				P				K			
			OM	DM																
	%	g/kg FM	%		% DM	% FM	g/kg FM	g/kg DM	% DM	% FM	g/kg FM	g/kg DM	% DM	% FM	g/kg FM	g/kg DM	% DM	% FM	g/kg FM	g/kg DM

Table 4. Input data units for the sheet “Feeds”

The user must enter only one number per chemical composition indicator. Units of chemical composition indicators do not have to be similar for one feed. If there is an indicator of dry matter digestibility of the feed, then there is no need to enter the organic matter digestibility and ash content indicator. All necessary recalculations are made automatically. All feeds that are entered in the table are available on “Feedin” sheets.

Determination of the grass amount consumed by grazing (per herd and year)

The grass intake depends on the age and species composition of plants. Dairy cows are able to consume daily up to 80 kg of grass (average 50-60 kg). For young cattle, it depends on their age (an average is 20-30 kg).

The grass yield per hectare and chemical composition depends on the grassland type and the number of cuts. For example, in Estonia, the average yield of cultural grassland is eight t/year/ha (3 cuts), for natural grassland (meadow), it is a lot less. According to the German fertiliser ordinance, the average yield of cultural grassland for three cuts is eight tonnes of grass dry matter ha.

Formulas for calculation grass intake per herd and year:

Grass, t: Number of animals grazed x average grass consumption kg/day/1000 x grazing days/year or

Grass, t: Grazed area (ha) x average grass yield (t/ha)

1.2 Cattle

1.2.1 Sheets “FeedIn cattle (TMR)” and “FeedIn cattle (AFC)”

Use only one option to enter data. Second choice is automatically locked.

Terms and definitions:

TMR – totally mixed ration. All ration components (feeds) are mixed. TMR has been prepared according to the nutritional factors need of the animal group. Are fed to animals *ad libitum.*

AFC – annul feed consumption.

Average weight, kg (dairy cows, TMR: field L17; AFC: field S15) – average annual body weight of the cow. Depends on the breed, for large breeds 600 kg, for light breeds 420 kg.

Mature weight, kg (dairy cows, TMR: field L18; AFC: field S16) – average body weight of the cow before calving. Depends on the breed, for large breeds 640 kg, for light breeds 440 kg.

Calving age, months (heifers, TMR: field Y16; AFC: field AC14) – heifers average age in calving. Average 24-26 months.

Starting weight (calf), kg (suckler cows, TMR: field BY17; AFC: field BQ15) – calf birth weight. Depends on the breed, for large breeds 40 kg, for light breeds 25 kg.

Final weight (calf), kg (suckler cows, TMR: field BY18; AFC: field BQ16) – calf body weight at weaning.

Calving interval, days (dairy cows, suckler cows TMR: field L177 and BY177, calculated automatically) - period (days) between two calving's. All lactation phases + dry period are covered. Can be longer than 365 days.

Days in the group (TMR) – number of days in the feeding croup

TMR loss, % (TMR) – TMR residue removed from the animal building (average percentage per day)

Realization (slaughtering) age, days (beef cattle (age 6 months to slaughtering) TMR: field AL177, calculated automatically; AFC: field AM14 – beef cattle age (days) from birth to realization (slaughtering). It depends on the intensity of production. In herds with intensive production an average is 14 months (420 days).

Duration of dry period, days (dairy cows, AFC: field S58) - length of dairy cow's dry period. Optimal dry period length is 40-60 days. Necessary only when the dry cows are kept separately in the barn or in the section with a different type of manure. For example, lactating cows – slurry system, dry cows – solid manure system.

1.2.2 Instructions for the use of the sheet "Feedin cattle (TMR)"

Enter the data for the groups of animals (i.e. dairy cows, heifers etc.) that are actually present in the barn. The remaining distributions will remain blank. Within a group of animals, all age groups (lactation phases) must be represented. If the feeding group's number is less than on the page, the remaining tables will remain empty.

Input data that is necessary in any case

The production data needed for correct calculations are described in figure 2.

Dairy cows	*Animal number, year cows*	1
	Milk yield, kg/year	10000
	Milk protein, %	3,20
	Average weight,kg	600
	Mature weight, kg	640

Figure 2. The production data (dairy cows) that is required for correct calculations

All green fields must be filled. The same applies to all cattle groups.

Entering feed data

Feeds are selected from the drop-down menu (Figure 3). The amount of feed (kg/day) ration must also be entered. All feeds that are entered on the sheet "Feeds" are available in the menu. All necessary calculations are done automatically.

Feeds (including mineral feeds)	Quantity kg/day	DM kg/day	DM digestibility %	CP g/day	P g/day	K g/day
Silage 1 (dry)	30,0	13,5	53,2	1229	27,0	216,0
Hey	2,0	1,7	55,7	133	3,8	29,9
Barley	5,0	4,3	81,8	593	21,5	23,7

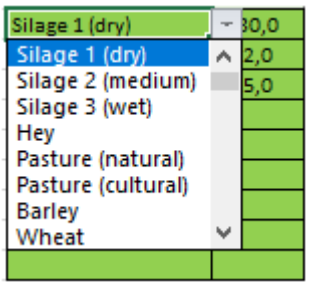


Figure 3. Entering feed data (TMR)

1.2.3 Instructions for the use of the sheet "Feedin cattle (AFC)"

Input data that is necessary in any case

The production data that is needed for correct calculations is described in figure 4.

Dairy cows	*Animal number, year cows*	100			
	Milk yield, kg/year	10000			
	Milk protein, %	3,2			
	Average weight,kg	600			
	Mature weight, kg	640			
	Grazing	*Days per year*	0	*Hours per day*	0

Figure 4. The production data (dairy cows) that is required for correct calculation

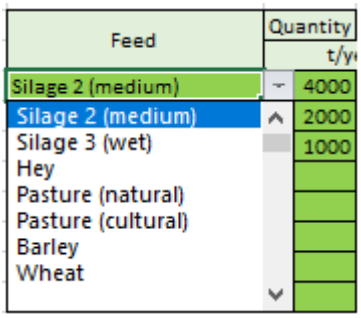
All green fields (except grazing) must be filled. The same applies to all cattle groups.

Entering feed data

Feeds are selected from the drop-down menu (Figure 5). The amount of feed (t) used during the year is also entered. All feeds that are entered on the sheet "Feeds" are available in the menu. All necessary calculations are done automatically.

Feed	Quantity	DM	DM digestibility	CP	P	K
	t/year		%	t/year		
Silage 2 (medium)	4000	1200,0	51,8	109,20	2,40	19,20
Hey	2000	1660,0	55,7	132,80	3,82	29,88
Barley	1000	860,0	81,8	118,68	4,30	4,73

Figure 5. Entering feed data (AFC)



1.3 Pigs

1.3.1 Sheets “FeedIn pigs (Intensive)” and “FeedIn pigs (AFC)”

Use only one option to enter data. Second choice is automatically locked.

Terms and definitions:

Starting weight, kg (slaughter pigs, Intensive: field G7, AFC: field T7) – body weight at the beginning of fattening.

Starting weight, kg (weaners, Intensive: field R7, AFC: field AE7) – body weight at the beginning of weaning.

Final weight, kg (slaughter pigs, Intensive: field G8, AFC: field T8) – body weight at the end of fattening.

Final weight, kg (weaners, Intensive: field R8, AFC: field AE8) – body weight at the end of weaners period.

Starting age, days (slaughter pigs, Intensive: field G9) – age at the beginning of fattening.

Starting age, days (weaners, Intensive: field R9) – age at the beginning of weaning.

Rearing period, days (slaughter pigs, Intensive: field L108, calculated automatically; AFC: field T9) – length of fattening period.

Rearing period, days (weaners, Intensive: field W108, calculated automatically; AFC: field AE9) – length of weaners period.

Free and gestation period, %DM (sows, Intensive: field AA112, calculated automatically; AFC: field AP47) – distribution of total feed DM intake per year between free, gestation and lactation period. Should be about 70%.

Lactation period, %DM (sows, Intensive: field AA113, calculated automatically; AFC: field AP48) – distribution of total feed DM intake per year between free, gestation and lactation period. Should be about 30%.

Outside period (AFC) – needed only when the pigs have access to the outside areas and manure is not collected from there.

1.3.2 Instructions for the use of the sheet “Feedin pigs (Intensive)”

Enter the data for the groups of pigs that are actually present in the barn. For sows, scroll down for lactation period. The remaining distributions will remain blank. The feeding is divided into phases depending on the age of the pigs (slaughter pigs, weaners) or reproduction cycle (sows). If the number of feeding phases is less than on the page, the remaining tables will remain empty (For sows at least one table for free and gestation period (columns Y – AH, lines 14 – 26) and one table for lactating period (columns Y – AH, lines 71 – 83) should be filled).

Input data that is necessary in any case

The production data that is needed for correct calculations is described in figure 6 (intensive) and figure 7 (AFC).

Slaughter pigs	*Pigs number, animals produced*	1
	Starting weight, kg	31
	Final weight, kg	110
	Starting age, days	90

Figure 6. The production data (slaughter pigs) that is required for correct calculations (intensive)

All green fields must be filled. The same applies to all pigs' groups.

Slaughter pigs	*Pigs number, animals produced*	1
	Starting weight, kg	30
	Final weight, kg	100
	Rearing period, days	100

Figure 7. The production data (slaughter pigs) that is required for correct calculations (AFC)

All green fields must be filled. The same applies to all pigs' groups. If the "AFC" sheet is used, then it is mandatory to also fill fields describing sows dry matter consumption ratio at lactation and free period (Figure 8).

Distribution of feed DM	Free and gestation period	70,0
	Lactation period	30,0

Figure 8. Distribution of feed dry matter (AFC)

Entering feed data

See chapter "Cattle" for instructions. Feeds are selected from the drop-down menu. The amount of feed (g/day) ration (intensive) or amount of feed (t) used during the year (AFC) should be entered. All feeds that are entered on the sheet "Feeds" are available. All calculations are done automatically.

1.4 Poultry

1.4.1 Sheets "FeedIn poultry (Intensive)" and "FeedIn poultry (AFC)"

Use only one option to enter data. Second choice is automatically locked.

Terms and definitions:

Herd type (laying hens, Intensive: field G6, AFC: field T6), selected from drop-down menu – depends on the housing system.

Starting weight, kg (laying hens, Intensive: field G9, AFC: field T9) – birds body weight at the beginning of laying period.

Starting weight, kg (chicken broilers, Intensive: field R9, AFC: field AE9) – birds body weight at the beginning of fattening.

Starting weight, kg (young birds, Intensive: field AC9, AFC: field AP9) – birds body weight after hatching.

Final weight, kg (laying hens, Intensive: field G10, AFC: field T10) – birds body weight at the end of laying period.

Final weight, kg (chicken broilers, Intensive: field R10, AFC: field AE10) – birds body weight at the end of fattening.

Final weight, kg (young birds, Intensive: field AC10, AFC: field AP10) – birds body weight before moving to layers or broilers group.

Starting age, days (laying hens, Intensive: field G11) – birds age at the beginning of laying period.

Starting age, days (chicken broilers, Intensive: field R11) – birds age at the beginning of fattening.

Rearing period, days (laying hens, Intensive: field L110, calculated automatically; AFC: field T11) – length of laying period.

Rearing period, days (chicken broilers, Intensive: field W110, calculated automatically; AFC: field AE11) – length of fattening period.

Rearing period, days (young birds, Intensive: field AH110, calculated automatically; AFC: field AP11) – length of the period before moving to layers or broilers group.

Outside period (AFC) – needed only when the birds have access to the outside areas and manure is not collected from there (Free range or organic hens).

1.4.2 Instructions for the use of the sheet “Feedin poultry (Intensive)”

Enter the data for the groups of birds that are actually present in the building. The remaining distributions will remain blank. The feeding is divided into phases depending on the age of the birds (broilers, young birds) or laying phase (laying hens). If the feeding phase’s number is less than on the page, the remaining tables will remain empty.

Input data that is necessary in any case

The production data that is needed for correct calculations is described in figure 9 (intensive) and

Laying hens	Herd type	Cage hens
	Birds number, year hens	100
	Egg production, kg/year hen	20,2
	Starting weight, kg	1,80
	Final weight, kg	3,00
	Starting age, days	118

Figure 9. The production data (laying hens) that is required for correct calculations (intensive)

figure 10 (AFC)

All green fields must be filled. The same applies to all poultry groups.

Laying hens	Herd type	Cage hens
	Birds number, year hens	100
	Egg production, kg/year hen	20,2
	Starting weight, kg	1,8
	Final weight, kg	2,6
	Rearing period,days	400

Figure 10. The production data (laying hens) that is required for correct calculations (AFC)

All green fields must be filled. The same applies to all poultry groups.

Entering feed data

See chapter “Cattle” for instructions. Feeds are selected from the drop-down menu. The amount of feed (g/day) ration (intensive) or amount of feed (t) used during the year (AFC) should also be entered. All feeds that are entered on the sheet "Feeds" are available in the drop down menu. All necessary calculations are done automatically.

2 EX-HOUSING

The annual amount of manure (ex-housing) is calculated from the following formulas:

Manure (ex-housing), kg/year = Manure (ex-animal), kg/year + Inputs (bedding, technological water, etc.), kg/year – losses (N-emission, dry matter loss, water evaporation), kg/year – manure applied directly to the field during grazing period, kg/year.

Manure amount at ex-housing level depends mainly on the animal keeping technology. Table 5 lists and describes all keeping technologies available in the tool standard version (adding more technologies is described in the chapter “Technology”).

The keeping technology should be selected from drop-down menu separately for every animal category or age group (Sheet: Ex- housing and ex-storage, column D)

Table 5. *List and short description of the keeping technologies available in the tool standard version*

Animal species	Keeping technology, manure removal system	Description of keeping technology
Cattle	Tie-up housing system (manure removal with scraper)	Tie stalls with open manure gutter behind the cows. Solid manure which is a combination of faeces and bedding is removed by a scraper. Liquid manure (=urine) is drained to a liquid manure tank or slurry tank.
	Tie-up housing system, grates	Tie stalls with manure gutter with grates behind the cows. Manure and urine is collected and stored together as slurry.
	Cubicles with solid floor	Loose housing with cubicles. Barn with solid floor without slats or drain in the walking alleys. The floor is cleaned by scraping approx. two times per day.
	Cubicles with slatted floor (manure channel, continuous removal)	Loose housing with cubicles. Barn with slatted floor in the walking alleys. Manure in the manure channels under the slatted floor is removed by means of manure scraper four times per day.
	Deep litter (whole area)	Loose housing. Deep litter in both resting area and area in front of the feeding bunker.
	Deep litter with long feeding area and solid floor	Loose housing. Deep litter in resting area. 60% of faeces and urine excreted in deep litter and 40% is excreted in slurry. Solid floor without slats or drain in front of the feeding bunker. Manure from this area is removed by a scraper.
	Deep litter with long feeding area and fast drying floor (scraper and urine drainage)	Loose housing. Deep litter in resting area. 60% of faeces and urine excreted in deep litter. Solid floor with drainage in front of the feeding bunker. Slope of min 2% towards drain. Scraper on top of the floor. Max 5% of the floor area is allowed to be open to drain the liquid.
	Deep litter with short feeding area and solid floor	Loose housing. Deep litter in resting area. 60% of faeces and urine excreted in deep litter. Solid floor without slats or drain in front of the feeding bunker. Manure from the solid floor is pushed/scraped into the deep litter.
	Boxes with slatted floor	Loose housing in pens without cubicles. Fully slatted floor with slurry channels or pits underneath.

Pigs	Partially slatted floor (50-75%)	Partially slatted floor. 50 - 75 % solid floor and remaining floor is slatted floor.
	Partially slatted floor (25-49%)	Partially slatted floor. 25 - 49 % solid floor and remaining floor is slatted floor.
	Drained and slatted floor (33/67)	Drained floor with max 10% opening to underlying slurry pit in 33% of animal occupied area and slatted floor in the remaining 67% of animal occupied area.
	Solid floor	Solid floor in whole pen area. Solid manure which is a combination of faeces and bedding is removed by means of a manure scraper. Liquid manure (=urine) is drained to a liquid manure tank or slurry tank.
	Deep litter (separate lying area)	Deep litter in resting area and slatted floor in the rest. Faeces and urine is assumed deposited by 50%/50% in the two areas.
	Deep litter	Deep litter in the whole area.
	Individual housing, *sows*, (partially slatted floor)	Individual housing in crates. Partially slatted floor (min. 90 cm solid floor in front of the crate).
	Individual housing, *sows,* (fully slatted floor)	Individual housing in crates. Fully slatted floor.
	Individual housing (solid floor)	Solid floor. Solid manure which a combination of faeces and bedding is removed by means of a manure scraper. Liquid manure (=urine) drained to a liquid manure tank or slurry tank.
	Loose housing (deep litter and solid floor)	Loose housing. Deep litter and solid floor. 33% at faeces and urine is excreted in the deep litter and the remaining 67% on the solid floor. Solid manure is a combination of faeces and bedding and is removed by means of manure scraper. Liquid manure (=urine) is drained to a liquid manure tank or slurry tank.
	Farrowing pens (partially slatted floor)	Farrowing pens. Partially slatted floor. Typically 150 cm solid floor in front of the crate.
	Farrowing pens (fully slatted floor)	Farrowing pens. Fully slatted floor.
	Two climate pens, *weaners*, (partially slatted floor)	Two climate pens. Partially slatted floor. Typically 50 - 70 % solid floor.
Poultry	Deep litter	Broilers: Solid floor with small amount of bedding put into the barn before the chickens come in.
	Cages, belt; manure drying	Laying hens: The manure is stored in a covered place. The manure is dried to approx. 40% dry matter content before storing.
	Cages, belt; solid manure	Laying hens: The manure is stored in a covered storage.
	Cages, belt; slurry	Laying hens: The manure is mixed with water to a dry matter content of approx. 12 %

	Aviary system (different levels of floors), belt, manure drying	Single or multi-tier system with different levels of floors with belts underneath to remove manure. Manure is stored in a covered storage
	Aviary system, slurry	Single or multi-tier system with different levels of floors with belts underneath to remove manure. The manure is mixed with water to a dry matter content of approx. 12%
	Free range, floor keeping	Solid floor with small amount of bedding put into the barn before the chickens come in
	Free range, (different levels of floors), belt, manure drying	Single or multi-tier system with different levels of floors with belts underneath to remove manure. Manure is stored in a covered storage. The manure is dried to approx. 40% dry matter content before storing.

If the dry cows are kept separately in the barn or section with a different type of manure then the keeping technology for lactating cows must be selected from drop-down menu (Sheet: Ex-housing and ex-storage, field D11) and for dry cows (Sheet: Ex-housing and ex-storage, field D12) respectively. If the manure system (manure type) for lactating and dry cows is the same, then field D12 has to be empty. The user must select an empty line from the drop-down menu.

The bedding type to be selected from drop-down menu (Sheet: Ex-housing and ex-storage, column G). Available bedding materials and their average chemical composition are described in the sheet “Technology”. Adding not listed bedding materials and also changing chemical composition is described in the chapter “Technology”. The bedding material must be selected separately for each animal group.

The amount of bedding (Sheet: Ex-housing and ex-storage, column H) is entered in kilograms per one animal (cattle, pigs), per 100 birds (laying hens, young birds) or 1000 birds (broilers) per day separately for each animal group. When animals are grazing, the annual amount of bedding is automatically calculated based on the length of the inside period (number of days inside).

The amount of technological water (Sheet: Ex-housing and ex-storage, column Q) is entered in tons per one animal (cattle, pigs), per 100 birds (laying hens, young birds) or 1000 birds (broilers) per year separately for each animal group. Only water (washing water for equipment, drinking water spillages etc.) that is removed with manure to the manure storage is counted. This is determined separately for each farm (group of animals). It is not calculated automatically.

The percentage of ammonia-N emission at ex-housing level (Sheet: Ex-housing and ex-storage, column S) selected automatically, depends on the choice of keeping technology. Changing ammonia-N emission factors described in the chapter “Technology”. The ammonia-N emission factor (%) at ex-housing level were calculated on the basis of ex-animal urine-N content. (Formula: Ammonia-N emission, % = Ammonia-N emission, kg ex-housing/urine-N, kg ex-animal x 100).

Dry matter and humidity (FM) losses at ex-housing level (Sheet: Ex-housing and ex-storage, column T) is entered as percentage separately for each animal group if deep litter manure system is used. If the manure drying technology is used in poultry farming, then humidity loss is calculated automatically. The percentage of loss of moisture is adjustable on the sheet “Technology”.

The solid manure/deep litter manure quantity and chemical composition (Sheet: Ex-housing and ex-storage, columns AU - BM) are calculated automatically. It depends on the choice of keeping technology and the amount of bedding and technological water added.

The liquid manure/urine quantity and chemical composition (Sheet: Ex-housing and ex-storage, columns BT - CC) are calculated automatically. It depends on the choice of keeping technology and the amount of bedding and technological water added.

The ammonia-N quantity emitted (Sheet: Ex-housing and ex-storage, column CT) is calculated automatically for each animal group separately. It depends on the choice of keeping technology.

The concentration of nitrogen, phosphorus and potassium in the solid manure/deep litter manure and liquid manure/urine (Sheet: Ex-housing and ex-storage, columns CU - CZ) are calculated automatically for each animal group separately.

The results of manure ex-housing per animal building or buildings where the manure collected to the same manure storage or storages (Sheet: Ex-housing and ex-storage, columns DG - DM) are calculated automatically. The manure types (storing technologies) selected automatically. It depends on the choice of keeping technology. The manure storing technologies are described in the chapter “Ex-storage”.

3 EX-STORAGE

The annual amount of manure (ex-storage) is calculated from the following formula:

Manure (ex-storage), kg/year = Manure (ex-housing), kg/year + Inputs (storage covering material, precipitation water, etc.), kg/year – losses (N-emissions, dry matter loss, water evaporation), kg/year – manure applied directly on the field, kg/year.

Manure type and amount at ex-storage level depending mainly from the animal keeping and manure storing technology. Manure types are described in table 6.

Table 6. *Manure types*

Manure type	**Description**[1]
Liquid manure	Any manure from housed livestock that flows under gravity and can be pumped. There are several different types of liquid manure arising from different types of livestock housing, manure storage and treatment.
Slurry	Faeces and urine produced by housed livestock, usually mixed with some bedding material and some water management to give liquid manure with a dry matter content of about 1-10%.

[1] Glossary of terms on livestock and manure management 2011, RAMIRAN

Solid manure	Manure from housed livestock that does not flow under gravity, cannot be pumped but can be stacked in a heap. May include manure from cattle, pigs, poultry, horses, sheep, goats and rabbits. There are several different types of solid manure arising from different types of livestock housing, manure storage and treatment.
Farmyard manure (FYM)	Faeces and urine mixed with large amounts of bedding (usually straw) on the floors of cattle or pig housing. May also include horse or stable manure. The manure is removed frequently (mostly daily).
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.

Manure storing technology depending on the manure type and animal keeping technology. Table 6 describes main manure storage technologies and connection to the animal keeping technologies.

Table 7. *Manure storing technologies.*

Manure type	**Storage type**	**Keeping technology examples (table 5)**
Solid manure Liquid manure	Solid manure storage or field heap Liquid manure storage or tank	Cattle: Tie-up housing system (manure removal with scraper). Pigs: Solid floor
Slurry	Liquid manure storage or tank	Cattle: Cubicles with solid floor Pigs: Partially slatted floor (50-75%) Poultry: Cages, belt
Solid manure	Solid manure storage or field heap	Cattle: Tie-up housing system (manure removal with scraper). Cubicles with solid floor (whole area). Pigs: Solid floor Bedding quantity is big. Manure removal is usually once per week.
Deep litter	Solid manure storage or field heap	Cattle: Deep litter (whole area) Pigs: Deep litter (whole area) Poultry: Aviary system, floor keeping
Deep litter Liquid manure	Solid manure storage or field heap Liquid manure storage or tank	Cattle: Deep litter with long feeding area and solid floor Pigs: Deep litter (separate lying area)

In the calculation tool the codes of specific storage types are:

1 - Solid manure storage or field heap and liquid manure storage or tank

2 - Liquid manure storage or tank

3 - Solid manure storage or field heap (deep litter)

4 - Solid manure storage or field heap (deep litter) and liquid manure storage or tank

5 - Solid manure storage or field heap

The choice of specific storage type is automatic and depends on the choice of animal keeping technology. Calculations at ex-storage level are divided between animal species (Sheet: Ex-housing and ex-storage, column DO). Only the characteristics of the type of animal and the type(s) of manure for which the calculations are made are displayed (Sheet: Ex-housing and ex-storage, column DP).

The ammonia-N loss during the storing period depends directly on the covering type of manure storage (heap).

The storage covering type (Sheet: Ex-housing and ex-storage, column DQ) selected from drop-down menu for each displayed storage separately. Available covering types and specific ammonia-N emission factors are described in the sheet “Technology”. Adding not listed covering types and also changing ammonia-N emission factors is described in the chapter “Technology”.

The losses (emission factors) at ex-storage level (Sheet: Ex-housing and ex-storage, columns DR - DW) are selected automatically. Emission factors depend on the manure type (denitrification – deep litter; N_20-nitrogen – liquid manure/solid or deep litter manure), manure storing technology (field heap – leaching) and manure storage covering type (ammonia-N). Changing emission factors for N_20-nitrogen and denitrification are described in the chapter “Technology”.

The open surface area of the storage, m² (Sheet: Ex-housing and ex-storage, column DY) is entered separately for each storage.

The precipitation, mm/year (Sheet: Ex-housing and ex-storage, column DZ) is entered separately for each storage.

The dry matter loss, % (Sheet: Ex-housing and ex-storage, column AE) is entered separately for each manure type.

Manure quantity losses at ex-storage level depending at manure type and manure storage type. The largest dry matter loss is connected with deep litter (dry matter starts to decay already in the building and when stored in the storage). The largest manure quantity fluctuation is connected with liquid manure in the storage with natural crust (due to rainwater precipitation and evaporation).

The precipitation loss through the evaporation, % (Sheet: Ex-housing and ex-storage, column EB) is entered only if the storage is not roofed.

Water evaporation from the surface of the storage depends on the covering type. When the storage is roofed, then precipitation is not included to the calculations.

The humidity loss through the surface, kg/m² (Sheet: Ex-housing and ex-storage, column EC) is entered only if the storage is roofed.

The proportion of manure directly applied on field, % (Sheet: Ex-housing and ex-storage, column ED) is entered only when some part of deep litter manure is spread directly from animal building to the field.

The results of manure ex-storage per animal building or buildings where the manure is collected to the same manure storage(s) (Sheet: Ex-housing and ex-storage, columns EJ - FB) are calculated automatically.

The losses (gaseous and leaching) at ex-storage level (Sheet: Ex-housing and ex-storage, columns FC - FH) are calculated automatically.

4 SHEET "TECHNOLOGY" (Database)

The table "Keeping technology, manure removal system" (Sheet: "Technology", columns B - E) lists all keeping technologies available in the standard version of calculation tool at ex-housing level and also all emission factors and codes that are needed for calculations.

4.1 Adding or modifying data in table "Keeping technology, manure removal system"

1. Changing ammonia-N emission factors at ex-housing level for listed keeping technologies and animal categories (Sheet: "Technology", column D). The purpose of the replacement can be using country-specific data. Emission factor should be replaced separately for every animal group and technology.

2. Adding keeping technology not listed in the table. The new technology will be added to the empty line of the corresponding group of animals. Fields that must be filled in any case:

   - The name and short description of the keeping technology (Sheet: "Technology", column C). The added technology is automatically visible in the drop-down menu (Sheet: Ex-housing and ex-storage, columns D);

   - Ammonia-N emission factor (%) at ex-housing level (Sheet: "Technology", column D) for that specific keeping technology and animal group.

   - Code of manure storing type (Sheet: "Technology", column E). Manure storing types and codes are described in the chapter "Ex-storage".

3. Humidity evaporation (%) from poultry manure if manure drying technology is used (Sheet: “Technology”, column G from line 163). This should be modified and added only when the technology is applied.

The table “Emission factors ex-storage” (Sheet: “Technology”, columns G - W) lists all manure storing technologies and covering types available in the standard version of calculation tool at ex-storage level and also all emission factors that are needed for calculations. Emission factors are presented by animal species.

4.2 Adding or modifying data in a table “Emission factors ex-storage”

1. Changing nitrogen emission and nitrogen, phosphorus and potassium leaching factors at ex-storage level for listed manure types and covering types (Sheet: “Technology”, columns K, M, N and O-W.). The purpose of the replacement would be to use country-specific data. Emission factors should be replaced separately for every manure type and covering method.
2. Adding covering method not listed in the table. The new method will be added to the empty line of the corresponding animal species, manure storing type and manure type. Fields that must be filled in any case: For example: animal species – cattle, manure type – slurry (Sheet: “Technology”, column L and M, line 22).
    - Field L 22 – the name and description on covering method. The added method is automatically visible in the drop-down menu (Sheet: Ex- housing and ex-storage, column DQ);
    - Field M 22 – the ammonia-N emission factor for that covering method.

5 SHEET “ADDITIONAL INFORMATION” (Database)

The table “Bedding” (Sheet: “Additional information”, columns B – F) lists all types of bedding material and their average chemical composition that is available in the standard version of calculation tool. If necessary, materials that are not listed can be added to the blank lines or the chemical composition of the existing materials can be modified.

The table “Default values: gain, foetus, milk, eggs” (Sheet: “Additional information”, columns H – L), lists all coefficients needed for manure nitrogen, phosphorus and potassium calculation at ex-animal

level per species and per age groups. If necessary all coefficients (Sheet: “Additional information”, column L) can be modified.

The table “Default values: manure DM, %” (Sheet: “Additional information”, columns N – R) lists all coefficients needed for manure quantity calculation at ex-animal level by species and by age groups. If necessary all coefficients (Sheet: “Additional information”, columns Q and R) can be modified.

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