Norwegian Environment Agency

Excretion of Dry Matter (DM) and Nitrogen (N) in Manure (Faeces and Urine) from pigs in Norway

Report covering the calculation of DM- and N-excretion from the different categories of pigs

Report

M-2580 | 2023

Colophon

Title – Norwegian and English: Excretion of Dry Matter (DM) and Nitrogen (N) in Manure (Faeces and Urine) from pigs in Norway

Summary – sammendrag:
The report presents the calculation of Dry Matter (DM and Nitrogen (N) in manure (faeces and urine) from pigs in Norway. The calculations are done for piglets after weaning, for breeding sows including nursing piglets until weaning, for growing-finishing pigs, and for recruitment sows (120 kg live weight (LW to 160 kg LW. The results of the calculations are shown in the Summary Table.
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TABLE 1. Main results of DM-excretion and N-excretion for the different categories of pigs. The figures are given as values per animal and day, and as animal per year (animals per day x 365 days) for breeding sows; values per animal and day and animal year for piglets; values per animal and day, and as values per animal, for growing-finishing pigs; and as values per animal for the recruitment sows.

	Total DM-excr. faeces+urine)	VS (Total -DM-excr. *0.9)	Total-N-excr. (faeces+urine)	TAN (ammonium-N)	N-excr., faeces
Breeding sow, from first parity (incl. nursing piglets)	0.816 kg DM/day	0.734 kg/day	62.82 g/day	41.88 g/day	20.94 g/day
Breeding sow from first parity (incl. nursing piglets)	298.0 kg DM/year	268.2 kg/year	22.93 kg/year	15.29 kg/year	7.64 kg/year
Piglets 10 – 30 kg LW	155 g DM/day	139.5 g/day	10.76 g/day	7.17 g/day	3.59 g/day
Piglets 10 – 30 kg LW animal years (33.5 days x 7.4 baches)	38.48 kg/animal year	34.63 kg/animal year	2.67 kg/animal year	1.78 kg/animal year	0.88 kg/animal year
Growing-finishing pigs 30 – 115 kg LW	384 g DM/day	345.6 g/day	22.60 g/day	15.07 g/day	7.53 g/day
Growing-finishing pigs 30 – 115 kg LW	38.9 kg/animal	34.63 kg/animal	2.291 kg/animal	1.527 kg/animal	0.764 kg/animal
Recruitment sows 120 – 160 LW	30.2 kg DM/animal	27.18 kg/animal	2.267 kg/animal	1.511 kg/animal	0.756 kg/animal
Recruitment sows, 120 – 160 LW. Per day, 55 days	549 g DM/day	491.1 g/day	41.22 g/day	27.47 g/day	13.75 g/day

recruitment period					
Recruitment sows, old definition, 30 kg LW to first farrowing.	145.6 kg DM/year	126.04 kg/ year	15.05 kg /year	10.03 kg/year	5.02 kg/year

1. PIGLETS AFTER WEANING (piglets in the period from 10 – 30 kg live weight (LW))

The average weaning age for piglets in Norway is 33.5 days (Ingris 2022), and the average weaning weight of the piglets was 10.6 kg in 2022 (Ingris 2022). The pigs are defined as piglets until they reach approx. 30 kg LW. The Ingris statistic report (Ingris 2022) shows that the average weight at the end of the piglet period was 32.2 kg, and the number of days from weaning to the end of the piglet period is 35 days.

The amounts of faeces and urine are calculated using the following values: Feed used for each piglet in the period from 10 to 30 kg LW is calculated to be 35.7 Feed Units net, FUn, the daily weight gain DWG) in this period is 619 g, and FUn per kg weight gain is 1.65 FUn/kg (Ingris 2022). One FUn is equal to 8.88 MJ Net Energy (NE). The piglet feed is assumed to contain 1.16 FUn/kg feed, so 35.7 FUn is equivalent to 30.8 kg feed (35.7 FUn / 1.16 FUn per kg feed). The piglet feed has 89% Dry matter (DM), and the digestibility of DM is 85% (apparent total tract digestibility – ATTD). The calculated content of feed DM per piglet is 27.4 kg DM, and the amount of digested DM for each piglet is 23.3 kg DM. It is assumed that the DM-content in faeces is 25%, and that the excretion of urine is 2 kg per kg feed-DM. The DM-content in urine is assumed to be 2%. The values used here are based on several digestibility experiments in Norway (unpublished), and on values from Danish studies (Poulsen et al. 2001, 2011, 2012).

A Norwegian piglet feed contains 1.16 FUn pr kg and has ca. 160 g crude protein /FUn. The calculation from content of crude protein (CP) to content of N in the feed is done using the factor 6.25 (160 g N/kg CP), therefore the piglet feed contains 25.6 g N/FUn.

With these assumptions in mind, the amount of faeces-DM is calculated to be **4.1 kg faeces-DM per piglet** (27.4 kg feed-DM – 23.3 kg digested feed-DM), while the **urine-excretion is 1.1 kg urine-DM** [(27.4 kg feed-DM x 2 kg urine/kg feed-DM) x 2 % DM in urine/100]. The total amount of DM-excretion (faeces + urine) per piglet after weaning is: 4.1 kg + 1.1 kg = **5,2 kg DM in the period from 10 – 30 kg LW**.

The average excretion of DM in faeces and urine per piglet and day in the period (10 – 30 kg LW: Total DM-excretion per piglet / 33.5 days = 5.2 kg DM / 33.5 days = **0.155 kg DM-excretion per piglet per day (155 g DM-excretion per piglet per day)**.
Volatile solids (VS) is calculated as DM-excretion x 0.9 (expert estimate by Kjos, based on values from faecal analyses in digestibility experiments with pigs at NMBU). VS for piglets per day = 155 g DM per day x 0.9 = **139.5 g VS for piglets per day**.

It is of interest to calculate the amount of DM-excretion per piglet per year, and this calculation can be done by assuming a batch operating system of 7 weeks, giving 7.4 piglet

batches per year (52 weeks per year / 7 weeks per batch). The value per animal years is 5.2 kg DM-excretion per piglet x 7,4 piglet batches per year = **38.48 kg DM-excretion per animal years**. The value for VS per piglet animal years is **34.63 kg VS per animal years**.

The nitrogen-excretion in faeces and urine from piglets are calculated assuming that 1 kg piglet gain demands 1.65 FUn (Ingris 2022), and that the accretion of N per kg piglet growth is 26 g N (Poulsen et.al. 2001, SEGES 2020).

The N-excretion from faeces and urine is calculated as the difference between given N in the feed and accreted N by the piglets, according to the following formula:

N-excretion per piglet per kg weight gain
= 1.65 FUn/kg weight gain x 25.6 g N/FUn in feed – 26 g N/kg weight gain

If the weight gain of the piglet is 22.2 kg (32.2 kg LW – 10 kg LW), this gives:

N-excretion per piglet per kg weight gain = (1.65 x 25.6 – 26) g N/kg weight gain = 16.24 g N/kg weight gain. For a weight gain of 22.2 kg this gives: **360,53 g N-excretion per piglet from 10 - 32.2 kg LW**.

The average N-excretion per piglet per day in this period: Total N-excretion per piglet / 33.5 days = 360.53 g N / 33.5 days = **10.76 g N-excretion per piglet per day**.

The average N-excretion per piglet per year: Total N-excretion per piglet per day x 365 days = 0.01076 kg N/day x 365 days = **3.93 kg N-excretion per piglet per year**.

Ammonium-N (TAN) is calculated as 2/3 of total N-excretion, and N-excretion, faeces is 1/3 of total N-excretion (expert estimate by Kjos, NMBU). For piglets, TAN = 10.76 g N-excretion per piglet per day x 2 / 3 = **7.17 g TAN per piglet per day**. N-excretion, faeces is 10.76 g N-excretion per piglet per day x 1 / 3 = **3.59 g N-excretion in faeces per piglet per day**.

The values for piglet animal years, using 7.4 piglet batches per year, are: **Total N-excretion = 2.67 kg per animal year; TAN = 1.78 kg per animal year; N-excretion faeces = 0.88 kg per animal year.**

2. BREEDING SOWS (including nursing piglets until weaning)

A breeding sow in Norway in average weans 29.5 piglets per year. (Ingris 2022).

A breeding sow per year is assumed to have 2.23 parities (pregnancies) per year. Our definition of a breeding sow is a sow from the start of her first parity to culling after her last parity and nursing period. A breeding sow per year is calculated as average values for each parity cycle multiplied 2.23.

The amounts of faeces and urine are calculated using the following values: Feed used pr breeding sow per year is taken from a large dataset collected by Norsvin, and data from "TN70 Feed Manual" (Norsvin 2023), and the feed intake per sow per year is 1497.3 FUn (1457 FUn for pregnancy and nursing, and 40.3 FUn as the feed intake for the nursing piglets). The average net energy content in the sow feed is 1.07 FUn/kg, and for the nursing piglet feed it is 1.16 FUn/kg. The value of 1497.3 FUn is equivalent to 1396.4 kg feed. The feed is assumed to contain 89% DM, and the digestibility (ATTD) of DM is 81%. Per sow per year the amount of feed-DM is 1242.8 kg DM, and 1006.7 kg digested feed-DM. The calculated amount of feed for the sow per year includes estimated feed for the sow's own weight gain, equal to 150 kg weight gain from the start of the first parity until the sow has reach her final live weight (approx. 310 kg). If assumed that a sow has 3 parities in average during her life, this can be calculated to 50 kg weight gain per parity. With 2.23 parities per sow per year this is 50 kg x 2.23 = 111.5 kg weight gain per sow per year. The small amount of feed eaten by the nursing piglets (estimated to 1.17 kg feed per nursing pig, and 34.8 kg for 29.5 piglets {34.8 kg x 1.16 FUn/kg = 40.3 FUn}) is included in the feed given to the breeding sows, as shown above. Estimated feed intake for nursing piglets is taken from SEGES Videncenter Svin, Denmark (internal document, year not shown).

The amounts of faeces and urine are calculated using the following values: Faeces from the sows contains 30% DM, the excretion of urine is 2.5 kg per kg feed-DM eaten by the sows and 2.0 kg per feed-DM eaten by the nursing piglets. The DM-content in urine is 2%. The values used here are based on several digestibility experiments in Norway (Kjos, unpublished), and on values from Danish studies (Poulsen et al. 2001, 2011, 2012).

A typical Norwegian feed for breeding sows (calculated as the average of diets for pregnancy and nursing, nursing feed has higher contents of FUn of crude protein than pregnancy feed) is calculated to contain 1.07 FUn per kg feed and has 142 g crude protein/FUn. The content of N in the feed is 142/6.25 g N/FUn = 22,72 g N/FUn.

With these assumptions in mind, the amount of faeces-DM is calculated to 236.1 kg per sow per year (1242.8 kg feed-DM – 1006.7 kg digested feed-DM), while the urine-excretion is 61.8 kg DM [[(1242.8 kg feed-DM x 2.5 kg urine/feed-DM) x 2 % DM in urine/100] + [(30.9 kg feed-DM x 2.0 kg urine/feed-DM) x (2% DM in urine/100)] = 60.6 kg urine-DM + 1.2 kg urine-DM = 61.8 kg urine-DM. The total amount of DM-excretion (faeces and urine) per sow per year inclusive nursing piglets is: 236,1 kg + 61.8 kg = **298.0 kg DM excretion per sow**

per year. Volatile solids (VS) is calculated as 298.0 g N-excretion x 0.9 = **268.2 kg VS per sow per year**.

The average excretion of DM in faeces and urine per day for the breeding sow inclusive nursing piglets per year: Total DM-excretion per sow per year / 365 days = 298.0 kg DM / 365 days = **0.816 kg DM-excretion per breeding sow per day (816 g DM-excretion per breeding sow per day)**. Volatile solids (VS) per sow per day is calculated as 0.816 g N-excretion per sow per day x 0.9 = **0.734 kg VS per breeding sow per day**.

The nitrogen excretion in faeces and urine for breeding sows including nursing piglets are calculated assuming that the accretion of N per kg weight gain for the sows is 27 g N (SEGES (2020), and that average weight gain is 111.5 kg per sow per year. The gain of the foetuses is calculated as the number of born piglets x average birth weight per piglet. For both the foetuses and for the nursing piglets the accretion of N is 25 g N per kg weight gain (SEGES 2020). The number of born piglets per parity is 16.1 piglets, resulting in 16.1 piglets x 2.23 = 35.9 born piglets per sow per year. The piglet weaning weight is 10.6 kg LW, og average birth weight is 1.6 kg, giving a weight gain of the piglets during the nursery period of 9.0 kg. The number of weaned piglets per sow per year is, as already mentioned, 29.5 piglets (Ingris 2022).

The N-excretion from faeces and urine is calculated as the difference between given N in the feed and accreted N by the breeding sow and the nursing piglets, according to the following formula:

N-excretion per breeding sow per year

= N given in the feed – N accreted by the sow – N accreted in the foetuses – N accreted in the nursing piglets

= 1497.3 FUn/sow per year x 22.72 g N/FUn/kg feed – 111.5 kg sow weight gain x 27 g N/kg sow weight gain – 35.9 born piglets x 16.6 kg foetus gain x 25 g N/kg foetus gain – 29.5 weaned piglets x 8.5 kg piglet weight gain x 25 g N/kg piglet weight gain

This gives the following value:

N-excretion per sow including nursing piglets per year = (1497.3 x 22.72 – 111.5 x 27 – 35.9 x 1.6 x 25 – 29.5 x 8.5 x 25) g N/sow per year = **22934 g N/sow per year = 22.93 kg N/sow per year**.

The average N-excretion per sow including nursing piglets per day: Total N-excretion per sow per year / 365 days = 22.93 kg N / 365 days = **0.06282 kg N-excretion per sow and day (62.82 g N-excretion per sow per day)**.

Ammonium-N (TAN) is calculated as 2/3 of total N-excretion, and N-excretion, faeces is 1/3 of total N-excretion. For breeding sows, TAN = 22.93 kg N-excretion per sow per year x 2 / 3 = **15.29 kg TAN per sow per year**. Calculated per sow per day the value for TAN is 62.82 g N-excretion per day x 2 / 3 = **41.88 g TAN per sow per day**. The values for N-excretion, faeces are **7.64 kg N-excretion in faeces per sow per year**, and **20.94 g N-excretion in faeces per sow per day**.

In the Norwegian emission estimates boars are also included in the inventory. Results from Norsvin research (Gjerlaug Enger, personal communication). shows that boars require 80 per cent of the feed used by sows. This assumption is used in calculating factors for total-DM, total-N and TAN for boars.

3. GROWING-FINISHING PIGS (30 kg LW – 115 kg LW (at slaughter))

The growing-finishing period is defined as the period from 30 kg LW to a LW 115 kg at slaughter.

The amounts of faeces and urine are calculated using the following values: The feed consumed by the growing-finishing pig is 2.67 FUn per kg weight gain (Ingris 2022), the feed contains 89% DM, and the digestibility (ATTD) of DM is 83%. The feed is estimated to contain 1.09 FUn/kg feed, and 138 g crude protein/FUn. The total weight gain of each pig is 85 kg, this results in a total feed intake of 227.2 FUn per pig, calculated as kg feed. This is 208.2 kg feed and 185.3 kg feed-DM during the growing-finishing period. The amount of digested feed-DM is 153.8 kg. The faeces of the pigs contain 25% DM, and the excretion of urine is 2 kg per kg feed-DM consumed. The content of DM in urine is 2%. The values used here are based on several digestibility experiments in Norway (unpublished), and on values from Danish studies (Poulsen et al. 2001, 2011, 2012).

With these assumptions the amount of faecal-DM is calculated to **31.5 kg** per growing-finishing pig (185.3 kg feed-DM – 153.8 kg digested feed-DM), while **urine-excretion is 7.4 kg DM**. [(185.3 kg feed-DM x 2 kg urine/kg feed-DM) x 2 % TS in urine/100]. The total excretion of DM (faeces + urine) is: 31.5 kg + 7.4 kg = **38.9 kg DM per growing-finishing pig**. Volatile solids (VS) is calculated as 38.9 g N-excretion x 0.9 = **35.01 g VS per growing-finishing pig**.

The excretion of DM in faeces and urine pr per pig per year, with 3.6 batches of growing-finishing pigs per year, is:

Total DM-excretion per pig per year = 38.9 kg DM per pig x 3.6 batches/year = **140.0 kg DM-**

excretion per pig per year. Excretion of DM in faeces (without urine-DM) per pig per year is 31.5 kg x 3.6 = 113.4 kg.

The average excretion of DM in faeces and urine per pig per day:
Total DM-excretion per pig per year / 365 days = 140.0 kg DM / 365 days = **0.384 kg DM-excretion per pig per day (384 g DM-excretion per pig per day)**. Volatile solids (VS) is calculated as 384 g N-excretion per pig per day x 0.9 = **345.6 g VS per pig per day**.

The feed contains 138 g crude protein/FUn. When calculated as g N/FUn this is 138/6.25 g N/FUn = 22.08 g N/FUn.

The carcass weight (carcass without head and feet), in percent of LW, (dressing-%) is in average 68% for a Norwegian growing-finishing pig.

The nitrogen-excretion in faeces and urine from growing-finishing pigs are calculated assuming that 1 kg piglet gain demands 2.67 FUn (Ingris 2022), and that the accretion of N per kg pig growth is 32 g N (SEGES 2020).

The N-excretion from faeces and urine is calculated as the difference between given N in the feed and accreted N by the pigs, according to the following formula:

N-excretion per pig per kg weight gain
= 2.67 FUn/kg weight gain x 22.08 g N/FUn in feed – 32 g N/kg weight gain

If the weight gain of the pig is 85 kg (115 kg LW – 30 kg LW), this gives:

N-excretion (faeces and urine) per pig per kg weight gain = (2.67 x 22.08 – 32) g N/kg weight gain = 26.95 g N-excretion/kg weight gain. For a weight gain of 85 kg this gives:
26.95 g N-excretion/ kg weight gain x 85 kg weight gain = **2291 g N-excretion per pig (2.291 kg N-excretion per pig in the period 30 – 115 kg LW**.

Ammonium-N (TAN) is calculated as 2/3 of total N-excretion, and N-excretion, faeces is 1/3 of total N-excretion. For a growing-finishing pig, TAN = 2.291 kg N-excretion per animal x 2 / 3 = **1.527 kg TAN per animal**. The values for N-excretion, faeces are **0.764 kg N-excretion in faeces per animal**.

The average N-excretion (faeces and urine) per pig per year, using 3.6 batches of pigs per year: Total N-excretion per pig x 3.6 batches = 2.291 kg N/day x 3.6 batches = **8.248 kg N-excretion per pig per year**.

The average N-excretion (faeces and urine) per pig per day in this period: Total N-excretion

per pig / 3655 days = 8.248 g N / 365 days = 0.0226 kg N-excretion per pig per day = **22.60 g N-excretion per pig per day**.

Ammonium-N (TAN) For a growing-finishing pig per day, TAN = 22.60 g N-excretion per animal per day x 2 / 3 = **15.07 g TAN per animal per day**. The value for N-excretion, faeces is **7.53 g N-excretion in faeces per animal**.

4. RECRUITMENT SOWS (120 kg LW – 160 kg LW)

The recruitment sow is defined as sow to be recruited as a breeding sow, and the recruitment period is from 120 kg LW until the first mating at approx. 160 kg LW. The live weight gain in this period is approx. 40 kg.

The amounts of faeces and urine are calculated using the following values: The feed consumed by the recruitment sows is 2.97 FUn per day (Norgesfôr 2023), and a feeding period of 55 days (40 kg weight gain /0.75 kg daily weight gain). The feed contains 89% DM, and the digestibility (ATTD) of DM is 83%. The feed is estimated to contain 1.01 FUn/kg feed, and 136 g crude protein/FUn.

The total feed intake in the recruitment period is 2.97 FUn/day x 55 days = 163 FUn. This is equal to 161.7 kg feed and 143.9 kg feed-DM. The amount of digested DM is 143.9 kg feed-DM x 83/100 = 119.5 kg digested feed-DM. The faeces of the recruitment sows contain 25% DM, and the excretion of urine is 2 kg per kg feed-DM consumed. The content of DM in urine is 2%. The values used here are based on several digestibility experiments in Norway (unpublished), and on values from Danish studies (Poulsen et al. 2001, 2011, 2012).

With these assumptions the amount of faecal-DM is calculated to **24.4 kg** per recruitment sow (143.9 kg feed-DM – 119.5 kg digested feed-DM), while **urine-excretion is 5.8 kg DM**. [(143.9 kg feed-DM x 2 kg urine/kg feed-DM) x 2 % TS in urine/100]. The total excretion of DM (faeces + urine) is: 24.4 kg + 5.8 kg = **30.2 kg DM excretion per recruitment sow**. Volatile solids (VS) is calculated as 30.2 g N-excretion x 0.9 = **27.18 kg VS per recruitment sow**.

When calculated per recruitment sow per day, assumed that the recruitment period is 55 days, this is: The total excretion of DM (faeces + urine) per animal per day is: 30.2 kg DM-exretion / 55 days = **0.549 kg DM excretion per recruitment sow**. Volatile solids (VS) is calculated as 30.2 g N-excretion x 0.9 = **0.491 kg VS per recruitment sow**.

The feed contains 136 g crude protein/FUn. When calculated as g N/FUn this is 136/6.25 g N/FUn = 21.76 g N/FUn.

The nitrogen-excretion in faeces and urine from the recruitment sows are calculated assuming that 1 kg of weight gain demands 4.07 FUn (163 FUn/40 kg weight gain), and that the accretion of N per kg weight gain is 32 g N (SEGES 2020).

The N-excretion from faeces and urine is calculated as the difference between given N in the feed and accreted N by the pigs, according to the following formula:

N-excretion per recruitment sow (120 kg LW to mating at 160 kg LW)
= (4.075 FUn/kg weight gain x 21.76 kg N/FUn – 32 g N/kg weight gain) x kg weight gain.

When the weight gain is 40 kg in the period this is:

N-excretion per recruitment sow = 4.075 FUn/kg weight gain x 21.76 g N/FUn – 32 g N/kg weight gain = 56.67 g N/kg weight gain.

40 kg weight gain x 56.67 g N/kg weight gain = 2267 g N.

This is 2.267 kg N-excretion per recruitment sow.

Ammonium-N (TAN) is calculated as 2/3 of total N-excretion, and N-excretion, faeces is 1/3 of total N-excretion. For a recruitment sow, TAN = 2.267 kg N-excretion per animal x 2 / 3 = **1.511 kg TAN per animal**. The value for N-excretion, faeces is **0.756 kg N-excretion in faeces per animal**.

When calculated per recruitment sow per day, assumed that the recruitment period is 55 days, this is: The total N-excretion from faeces and urine) per animal per day is: 2267 g N-excretion / 55 days = **41.22 g total N-excretion per recruitment sow per day**.

The values of ammonium-N (TAN) and N-excretion, faeces, per animal per day are as follows; TAN = 1.511 kg per animal / 55 days = 0.02747 kg TAN per animal per day = **27.47 g TAN per animal per day**. N-excretion, faeces, per animal per day = 0.756 kg per animal / 55 days = 0.01375 kg per animal per day = **13.75 g N-excretion, faeces, per animal per day**.

The older definition of recruitment sows was the period from 30 kg LW to the first farrowing (this period is in average one year). When the calculations for recruitment sows are performed using this definition, the following values are obtained: Total DM-excretion, 145.6 kg DM/year; VS, 126.04 kg/year; Total N-excretion, 15.05 kg/year; TAN, 10.05 kg/year;

N-excretion faeces, 5.02 kg/year. These values are shown in Summary, Table 1, in the line “Recruitment sows, old definition.

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The Norwegian Environment Agency is a government agency under the Ministry of Climate and Environment.

We work for a clean and diverse environment. Our primary tasks are to reduce greenhouse gas emissions, manage Norwegian nature and prevent pollution.

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