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Wageningen UR Livestock Research and Central Veterinary Institute of Wageningen UR, both part of Stichting Dienst Landbouwkundig Onderzoek (DLO Foundation), together with the Department of Animal Sciences of Wageningen University comprises the Animal Sciences Group of Wageningen UR (University & Research centre).

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February 2014

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Nitrogen and phosphorous excretion factors of livestock

Task 2 : In-depth analyses of selected country reports

Summary

General information

The amount of nitrogen (N) and phosphorus (P) excreted by livestock varies with several excretion factors. These excretion factors themselves vary with species and within species with the defined animal categories. The combined effect of excretion factors on the actual N and P excretion is defined by excretion coefficients. These excretion coefficients are used to estimate manure production for the estimation of nitrogen balances, GHG and NH_3 emissions as well as within the context of the Nitrates Directive for ensuring the respect of the limit 170 kg N/ha/year from animal manure. To be able to consistently estimate the nitrogen input to agricultural soils and nitrogen emissions across countries and to capture changes in farming practices (mitigation actions), excretion coefficients should be based on a common methodology using regularly updated statistics. Currently, there are no uniform and standardized methods in EU-27 for the calculation of Nitrogen (N) and phosphorus (P) excretion coefficients per animal category. A uniform and accepted categorization of farm animals is important for accurate accounting of the total N and P excretion, because of the large differences between animal categories and also within categories when animals of different age classes and productivity levels are grouped together.

Objectives and countries under consideration

The objectives are:

- To identify and analyse differences in methodologies and give an overview of their complexity, strengths and weaknesses for ten selected EU-27 countries.
- To point out the accuracy and reliability of the excretion coefficients in use in ten selected European countries.
- To compare the resulting excretion coefficients between the ten selected European countries and clarify differences.

The selected countries are Denmark, Estonia, France, Germany, Ireland, Italy, The Netherlands, Poland, Spain and the United Kingdom.

Methodological aspects

Nitrogen balances are used as indicators for several EU policies and are also closely related to other indicators such as GHG emissions and NH3 emissions. Currently consistency is lacking

(a) between nitrogen balances at national level reported for different policies,
(b) between nitrogen balances and other related indicators
(c) between national nitrogen balances of different countries due to:

1. different methodologies (farm/land/soil balances)
2. different data sources (survey/measurements/expert judgements)
3. different definitions (reference area, excretion including or excluding volatilisation)

Additional inconsistency may occur due to differences in terminology or in the basis for calculation of excretal output (e.g. animal categories, per animal produced or per animal place, annual or production cycle of the animal species).

Methods, building blocks and data origin

A number of methods exist for quantifying N and P excretion coefficients for livestock. They all use one of the following principles:

- Direct excretion measurements with livestock
- Direct measurements of manure in storage
- Metabolic and mechanistic models
- Input-output measurements (balance method)

The first three methods are useful for measurements of animal excretions, but less fit to estimate N and P excretion coefficients at farm, region or national level. This is mostly due to difficult quantification of the amounts produced and of obtaining representative samples. The remaining alternative is to use the input-output measurement, often referred to as 'balance method'. The balance method can be used at several scale levels: individual animals, groups of animals, barn, farm, region and country and is based on the 'law of mass conservation'. Therefore, within EU-27 this is the most commonly used method to estimate N and P excretions at national levels.

Categorization of farm animals

National total N and P excretions are calculated in principle as the registered animal numbers x average excretion per animal (kg/year). Animal numbers refer to different species and within species to different categories of animals. The sum of the excretions of each animal category represents the national total N and P excretions. Due to large differences in categorization of farm animals between countries, comparing average N and P excretions per animal per year as such is less meaningful. Existing systems for uniform categorization (e.g. Farm System Survey or Livestock registers) could facilitate comparison of countries. However, when uniform categorization differs from local animal categorization the local data have to be recalculated to fit to the new animal categories. The extent of the differences between local and uniform animal categories will determine the impact of these differences on the quality of calculated excretion coefficients.

Data origin

To calculate N and P excretion on a national level several levels of quality of data origin can be distinguished (best on top).

- Measurements input-output
- Modelling approach
- Measurements manure
- Defaults
- Expert judgement

These data origins may relate to different levels of observational units (e.g. animal, farm, region or country or animal category, animal species, common literature and country specific information). Extension with quality parameters as statistical reference and update interval is possible and enables qualitative comparison of different approaches in calculating excretion coefficients.

Results

Comparison of countries

For the ten countries under consideration a qualitative comparison of data origin and data quality was made, since a quantitative comparison is not possible. Except for Poland and Estonia all of these countries use the balance method. From the qualitative comparison it was concluded that the countries using the balance method have sufficient data quality to calculate accurate animal excretions, although differences occur.
The country reports showed a wide variation in excretion coefficients per animal category. This variation could be explained by two causes: (a) differences in the quality and accuracy of the calculations, and (b) differences between regions concerning animal husbandry system. These regional differences are the result of different diets, different animal breeds and/or different production levels. Most differences between countries using the balance method could be related to regional differences, but some differences remained unexplained due to lack of information.

Cattle

Regional differences in N and P excretion coefficients for cattle are large among the 10 selected countries. For dairy cattle it resulted in excretion coefficients for the average animal (regardless milk production level) to specific excretion coefficients for each production level and diet fed. For beef cattle similar observation were made. However, or both dairy and beef cattle these differences were over-all well explained by regional differences.

Pigs

For all categories pigs N and P contents in animals and diets showed variation due to regional differences. However, when combined into excretion coefficients most of the differences became less significant. Over-all the N and P excretion coefficients were relatively consistent over countries. Nevertheless some large differences in N excretion coefficients were observed. Some of them could not be explained from regional differences. For example, a low N-excretion of Spanish weaned piglets and growing-finishing pigs or a approximately 300% higher N-excretion of Polish growing-finishing pigs.

Poultry

The N excretion levels of broilers and laying hens are comparable for most of the countries, except for Poland and Spain, that have much lower N-excretion levels for both species. No explanation for these difference were found. The P-excretion levels of broilers and laying hens show some variation, but these could be explained from whether or not microbial phytase was used, the breeding strain and the length of the growing period.

Conclusions

The balance method is the best method available to estimate N and P excretion coefficients at national level. Accuracy and quality of the calculated excretion coefficients have to be derived from well documented data origin for all building blocks of the balance method. For the countries under consideration accessible documentation of data origin was available and N and P excretion coefficients were of sufficient accuracy and quality.

Comparing excretion coefficients between countries is difficult due to regional differences in animal husbandry systems and animal categorization. Uniform animal categorization may bring more clarity, but also may have a negative effect on accuracy and quality of the estimated N and P excretion coefficients. This becomes relevant when uniform animal categorization significantly differs from local categorization.

A common method to calculate total national N and P excretions for EU-27 countries was proposed.

Methods used in 10 selected EU-27 countries

Denmark

Denmark is strong in method used and data origin. The quality and accuracy of the calculated excretion coefficients is good. However, one combined category is used for breeding sows including piglets up to 7.3 kg, based on a performance level of 26 weaned piglets per sow per year. In some other countries, sub categories of breeding sows, e.g. rearing sows, boars, gestating sows and lactating sows, are distinguished. By use of different categories, the N and P excretion of breeding pigs might be estimated more precisely. In poultry the N and P contents in carcasses are similar for all kind of poultry categories, whereas in other countries different values for the distinguished categories are used. Likewise, N and P contents of broiler breeder eggs are similar to the contents in table eggs. Taking specific values per category into account might improve the accuracy of the national N and P excretion from poultry.

Estonia

The Estonian approach includes manure production for which default N contents are established. However, manure production is not a very constant value, because it depends on many factors. Moreover, because of N volatilisation, determination of the N content depends on the time after defecation. Similar large variations are found for default values for feed intake, feed composition N and feed digestibility and this negatively affects the accuracy of the estimated N excretion coefficients. Currently, no information is available regarding P excretion from livestock in Estonia.

France

The French system has to deal with a large variety of animals and regions. By using the modelling approach instead of input/output measurements transparency of method is ensured. Important is that data origin is of good quality, although in official documents only average data are represented.

Germany

The German system uses the modelling approach and is therefore not susceptible to variation or inaccuracy in input/output measurements. By choosing this less accurate methodology data origin becomes more important for the quality of the excretion coefficients. However, data origin is well documented and of good quality.

Ireland

Ireland uses a method that includes extensive industry consultation, involving producer organisations, specialist consultants, research scientists, industry experts and some farmers. The derived output figures have been compared with the relevant research data available. Recent research data for pigs and poultry have provided useful validation of the proposed outputs. Differences with similar standards or recommendations made elsewhere in Europe are generally minor.

Italy

The nitrogen excretions standards have been derived from nitrogen balance measurements on farm level at a number of farms in different regions. Although nitrogen balances of livestock animals may vary between regions, average values for nitrogen excretion per animal category are presented. It is not well documented how this average is calculated since no other information or reports have been obtained on the design and individual results of these farm balance measurements.

The Netherlands

The Dutch method is well documented and distinguishes many animal categories. Data origin is of good quality and estimated excretion coefficients are accurate. However, due to many animal categories and many different diets the method is complex.

Poland

The Polish approach is transparent and has relatively low variation in excretion coefficients between years. However, the methodology is based on estimations of manure production and contents in manure. The average feed composition and the average manure production have large variation, because they depend on many factors. Moreover, because of N volatilisation, determination of the N content of manure varies with time after defecation. Currently, no information is available regarding P excretion from livestock.

Spain

The method used in Spain to calculate the N excretion on the national level is strong, because it's an accumulation of the N excretion of all individual farms. The N excretion per farm is determined by the balance between N intake and N deposition (input/output measurements), which is well documented by each farmer. Data regarding feed intake levels and mineral retention per category are not available and no information is available regarding P excretion.

United Kingdom

Data origin is well documented and of good quality and includes extensive industry consultation, involving producer organisations, specialist consultants, research scientists, industry experts and some farmers. The derived output figures have been compared with the relevant research data available. Recent research data for pigs and poultry have provided useful validation of the proposed outputs. Differences with similar standards or recommendations made elsewhere in Europe are generally minor. It is emphasised that there are many influencing factors and the proposed ‘standard’ excretion coefficients should be used for general guidance only.

Table of contents

1 Introduction

1.1 General information

The total amounts of nitrogen (N) and phosphorus (P) excreted by livestock are large, but not well quantified (Steinfeld et al., 2006; Oenema and Tamminga, 2005; Davidson, 2009). The excretion of N and P depends on animal category and species, animal productivity, and feed composition. The total annual excretion per animal within a certain animal category is termed 'N and P excretion coefficients'.

These excretion coefficients are used among others to estimate the total manure N and P production for the estimation of gross N and P balances, greenhouse gas (GHG) and ammonia (NH_3) emissions (Oenema et al., 2011). Accurate estimates of manure N production are also needed within the context of the Nitrates Directive for ensuring the respect of the limit 170 kg N/ha/year from animal manure (EC, 1991). Evidently, to be able to consistently estimate the N input to agricultural soils and N emissions, and to capture changes in these inputs and losses following changes in farming practices (including mitigation actions), the excretion coefficients should be based on a common methodology using regularly updated statistics.

Currently, there are no uniform and standardized methods in EU-27 for the calculation of N and P excretion coefficients per animal category. A comparison of excretion coefficients used by countries in N balances reported to OECD/Eurostat (Danish Environmental Protection Agency, 2013) showed a wide variety in the quality and availability of these excretion coefficients across countries due to differences in methodologies and data quality and availability. For example, in some countries estimations have been based on expert judgements and literature data, because the required data were not easily available for all livestock categories or only for general categories and coefficients. In contrast, some other countries based the estimations on detailed animal input-output models, using statistical data, which are updated regularly. In short, Member States have developed their own method or simply use default values, which are often based on limited regional specific research. These methods all have advantages, disadvantages and associated uncertainties.

Excretion coefficients for N and P preferably must be calculated for specific animal categories, because of the large differences between animal categories in feed intake, N and P retention and hence in N and P excretion. Comparisons between countries concerning excretion coefficients for N and P are difficult because of differences in animal categorization. Uniform animal categories would make comparisons between countries and between systems more transparent and meaningful. There are different ways to categorize farm animals in functional groups. A main distinction is often made between monogastric animals (e.g. pigs, poultry) and ruminant animals (e.g. cattle, sheep), because of their differences in feed requirements, feed conversion rates and animal productivity. From an economic point of view, farm animals in EU-27 are usually categorized in dairy cattle, beef cattle, pigs, poultry, sheep and goat, and other animals (e.g., horses, deer, etc.). A uniform and accepted categorization of farm animals is important for accurate accounting of the total N and P excretion, because of the large differences between animal categories and also within categories when animals of different age classes and productivity levels are grouped together.

The general objective of the study "Nitrogen and phosphorus excretion factors for livestock", which is Lot 1 of "Methodological studies in the field of Agro-Environmental Indicators" (2012/S 87-142068) is "to bring clarity into the issue of excretion factors so that a recommendation on a single, common methodology to calculate N and P excretion coefficients can be identified. The study consists of seven Tasks, each with specific objectives. This report deals with Task 2 of the aforementioned study; it builds on the results of Task 1 and relates to an in-depth analysis of the methodologies and data used in ten selected countries within the EU-27.

1.2 Objectives and countries under consideration

The objectives of Task 2 are:
- Further in-depth analysis of methodologies used for calculating and reporting excretion factors in ten countries, to be as selected jointly by the contractor and Eurostat.
- To identify differences in methodologies and give an overview of their complexity, strengths and weaknesses, spatial scale, and the data requirements.
- To point out the accuracy and reliability of the excretion coefficients in use in ten selected European countries.
- To compare the resulting excretion coefficients between the ten selected European countries and clarify differences.

The selected ten countries are Denmark, Estonia, France, Germany, Ireland, Italy, The Netherlands, Poland, Spain and the United Kingdom.

1.3 Outline of the report

The first chapter briefly addresses the necessity to look into the methods used to calculate N and P excretion coefficients and points out the objectives of this report. Chapter 2 provides an overview of available methods to estimate excretion coefficients. Chapter 3 summarizes the information of Chapters 4 to 13 and analyses similarities and differences between the ten countries under consideration. Chapters 4 to 13 each contain a single country report of country specific methods used for the estimation of excretion coefficients. The final conclusions are drawn in chapter 14.

2 Methodological aspects related to the estimation of excretion factors

2.1 Introduction

Nitrogen balances are used as indicators for several EU policies and are also closely related to other indicators such as greenhouse gas (GHG) emissions and ammonia (NH_3) emissions. Currently consistency is lacking (e.g., Oenema et al., 2011):

(a) between nitrogen balances at national level reported for different policies,
(b) between nitrogen balances and other related indicators
(c) between national nitrogen balances of different countries due to:

1. different methodologies (farm/land/soil balances)
2. different data sources (survey/measurements/expert judgements)
3. different definitions (reference area, excretion including or excluding volatilisation)

Additional challenges in comparing for example the results of different countries can occur due to differences in terminology or in the basis for calculation of excretal output (e.g. animal categories, per animal produced or per animal place, annual or production cycle of the animal species). Similarly, when comparing excretion coefficients, it is important that the basis of the excretion coefficients is known and understood, and that comparisons are made only between what can be considered equivalent animal categories.

2.2 N and P excretion from livestock

The main factor that influences N and P excretion coefficients is the diet of the livestock. In fact, more than 50 % of the N and P contained in feed is excreted (Ryser et al, 2001, Table 2.1). Within species, the exact proportion excreted varies according to a range of factors including performance (e.g. amount of milk, meat and egg produced), age, sex and husbandry. Pigs and poultry, which are subject to relatively less variability in feeding regimes across EU Member States, should therefore present less variability in N and P excretion coefficients than cattle, sheep and goats. This also implies that consideration of the data produced by different MS cannot be separated from the differences in quality and composition of milk, meat and eggs. For example, pig diets for bacon production are not the same as for dry ham or the diet used for dairy cattle may vary between those producing consumption milk and those producing milk for cheese making.

Table 2.1 Percentage of dietary N and P excreted by livestock (adapted from Ryser et al., 2001)

Type of Animal	***N excreted (% of feed Intake)***	***P excreted (% of feed Intake)***
Dairy Cow	65-80	65-80
Growing Cow (beef)	75-80	70-85
Sow with piglets	75-80	75-85
Finishing Pig	70-80	75-85
Laying Hen	65-80	85-90
Broiler	55-65	50-65

2.3 Methods for quantifying excretion from livestock

2.3.1 Available methods

A number of methods exist for quantifying N and P excretion coefficients for livestock. They all use one of the following principles:

1. *Direct excretion measurements with livestock*
The measured excretions of individual animals provide in principle the most accurate estimate of the amounts of N and P excreted. These methods require either total collection of faeces and urine, or reliable markers for spot sampling. Direct measurements are expensive and time-consuming, and the values obtained can only be applied to similar types of livestock (breed, age, sex, growth rate, etc.) and diets. The results of this approach are in principle only applicable for the particular factors and environmental conditions prevailing during the period of observation and sampling and need (some) extrapolation when used for estimating excretions in different conditions.

2. *Direct measurements of manure in storage*
Estimates of the amounts of N and P excreted in manure by direct measurements and analysis of the manure stored in barns and/or manure storage facilities may be achieved at less cost (in terms of the number of samples and analyses required). However, the amounts of manure produced are difficult to quantify, and obtaining representative samples for analysis can be difficult. It also needs good administration of the manure already applied to the field until measurement of the manure in storage. Furthermore, this methods does not account for manure produced by pasturing animals (e.g. ruminants during grazing).

3. *Metabolic and mechanistic models*
These models aim to describe in detail the processes that go on within the body of the animal. An integral component of these models is a prediction of the partitioning of feed N and P into excreta N and P. Metabolic and mechanistic models are complex and because they tend to work on an individual animal basis are generally not suited to estimate whole farm application.

4. *Input-output measurements (balance method)*
Input-output measurements used for estimating N and P excretions by farm livestock assumes that the amounts of N and P excreted in faeces and urine is equal to the total amounts of feed N and P consumed minus the amounts of N and P in the animal products milk, meat, eggs, live weight gain, etc., respectively. This may be represented as:

N excreted = N intake – N in products
P excreted = P intake – P in products

2.3.2 Estimation of N and P excretion at a national level

Measuring the amounts of manure produced and analysing its N and P contents seems to be a logical approach to determine national N and P excretions. However, the limitations of this method (difficult quantification of the amounts produced and of obtaining representative samples) make it rather unfit for the estimation of N and P excretions at national level. An alternative would be direct excretion measurements with livestock. Although in principle of high accuracy, these measured excretions have the disadvantage of limited applicability. The assumptions or extrapolations needed to come to a higher level of aggregation than 'breed, age, sex, growth rate' and diets affect the accuracy of estimation often too much. This makes excretion measurements with livestock also rather unsuitable for estimation of national N and P excretions. The same arguments apply to the use of metabolic and mechanistic models since they depend on specific and exact data input, which is often related to individual animals, which are not easily made applicable for higher aggregation levels.

The remaining alternative is to use the 'balance method'. Input-output measurement is possible at several scale levels: individual animals, groups of animals, barn, farm, region and country. This method is based on the 'law of mass conservation', which is related also to the first law of thermodynamics. It assumes that the feed N and P which is not recovered in animal products (milk, meat, eggs, live weight gain), must end up in manure (faces and urine). The balance method allows distinction between animal categories, since excretions derived for different categories can be added together to calculate excretion at a different aggregation level. Therefore, within EU-27 this is the commonly used method to estimate N and P excretions at national levels.

2.4 Complexity of the balance method

Although the principle and the methodology of the balance method are simple and clear, the collection of the data needed may make the methodology complex.

The feed ration offered to the animals has large effects, and therefore needs to be known in detail. Distinctions can be made in for example the metabolizable energy content, protein content and digestible phosphorus content. This depends also on the available data.

Production level is also an important factor. It relates especially to the milk yield of dairy cows, but for example also to the number of piglets per sow and the live weight gain of fattening animals per day.

Management can have a significant effect as well, especially related to the feeding and herd management, including indoor climate, disease control, fertility control, etc.

2.5 Strengths and weaknesses of the different methods

The method of direct excretion measurement with livestock may be preferred from a scientific point of view, because it analyses literally the N and P excreted. However, these measurements are complex and expensive and therefore carried with only few variants; hence the resulting data generally apply to the limited conditions of experimental or model farms only. It is often questionable whether or not these data could represent actual farms.

The method of measurement of manure has difficulties relating to the fact that manure is very heterogeneous and that it is difficult to take representative samples and to measure the total volume of excretion under the conditions of a practical farm. The excretion has to be collected and measured over extended periods because of daily and/or seasonal variations. This further complicates taking representative samples from the excreted volume for analysis. Finally it is very complicated to measure or estimate the gaseous N losses that may occur during storage.

The method of using mechanistic/metabolic models is accurate when exact data about the feed composition and animal performances are available. However, often exact data are not available for actual farms and therefore models have to be adapted and adjusted to the available data of actual farms. Accurate predicting of excretion will become more difficult, because the accuracy of the model calculations in the end depends on the accuracy of the input data of the model.

The method of input-output measurements is accurate for individual animals in experimental conditions. For actual farms this method uses the farm balance to calculate average excretions. In this farm balance, N and P intake is measured and N and P retention in animals and products is estimated by using data from one or more of the three abovementioned methods. This calculation method may not be accurate enough to predict excretion of individual animals, but it is accurate in predicting the average excretion. Evidently, the accuracy of estimating excretions depends on the quality of available data. The common way to acquire data is that nutrition specialists provide typical input and performance data on which to base the calculations and, where possible, consider the views of the feed industry also. In this way, representation of appropriate classes of livestock types and productivity levels are achieved, e.g. milk production in dairy cows and live weight range in other animal categories.

2.6 Spatial scale

In animal sciences research, the individual animals are often object of study, also to find out (genetic) differences between different animals and their response to management factors, including animal diets. In most cases, however, the scale of interest is a farm, to estimate the performance of the farm and its scope for improvement.. In other cases, the region or a country is the scale of interest. A region may vary from a small agglomeration of a number of farms, to a catchment or an administrative unit (e.g., province, country, NUTS, 1, NUTS 2 or NUTS 3). The aspect of spatial scale is further discussed in Task 4 of the current project.

3 In- depth analysis and executive summary report

3.1 Categorization of farm animals

National total N and P excretions are calculated in principle as the registered animal numbers x average excretion per animal (kg/year). However, animal numbers refer to different categories of animals and thus to different N and P excretions per average animal in each category. In fact the national total N and P excretions have to be calculated as the sum of the excretions of each animal category. Large differences in categorization of farm animals between countries makes comparing average N and P excretions per animal per year as such less meaningful. On the other hand, the perhaps most important factor affecting the accuracy and quality of the calculated national N and P excretions is not the categorization of farm animals but 'data origin'. Data origin depends on accessibility of information about animal numbers within a specific category and estimates of N and P in feed and N and P retention in animal products. The availability of this information is usually related to 'big changes in the animals life' as (for pigs) birth, culling, transfers to different housing. At these moments animals are counted and often weighted and between these moments feed intake and feed composition could be registered. However, slaughter weight and age at each event described may differ per country or region due to differences in the dominant housing and/or feeding systems. In order to ensure the best data origin, animal categorization should be a reflection of the local animal husbandry system and measurements should refer to these categories. When existing systems for uniform categorization (e.g. Farm System Survey or Livestock registers) differ from local animal categories the local data have to be recalculated to fit to the new animal categories. The extent of the differences between local and uniform animal categories will determine the impact of these differences on the quality of calculated excretion coefficients.

3.2 Building blocks for the calculation of national excretions

3.2.1 National N and P excretion (kg N or P/year/national herd)

National excretions are predominantly calculated as:

registered animal numbers x average N or P excretion per animal (kg/year)

Building blocks:

- Animal numbers
    - Animal numbers per animal category
- Average N or P excretion per animal
    - Average N or P excretion per animal per animal category (kg N or P/year)

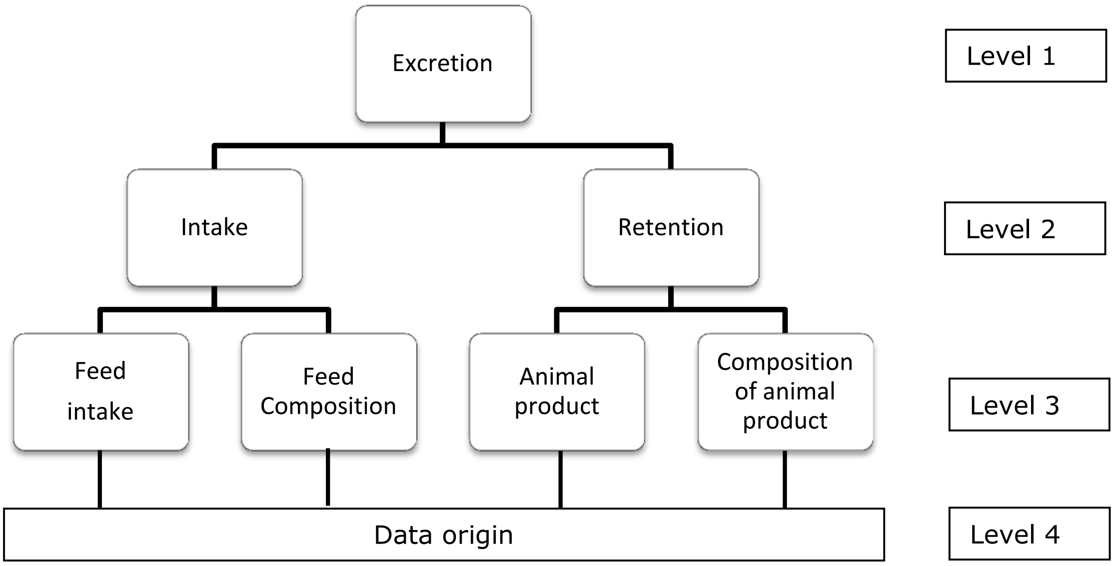
3.2.2 Average N or P excretion per animal (kg/year)

Within the ten EU-27 countries under consideration the average *ex animal* N and P excretions per animal (kg/year) are predominantly calculated by use of a balance method. For purpose of in-depth analysis of N and P excretion coefficients (*ex animal),* well defined inputs for this balance method are needed. Several elements (building blocks) within the balance method are distinguished. The information in a building block often is calculated from other sources of information, which are (sub)building blocks. To distinguish between building blocks and sub building blocks, different levels of building blocks can be defined. Figure 3.1 shows the building blocks levels[1] for the calculation of N and P excretion coefficient of a single animal (kg

[1] The building blocks levels of figure 3.1 are used in Task 3 chapter 6 to describe a common three-Tier approach to calculate national N and P excretion coefficients. Tier 1 corresponds with building block level 1 (EU-27 defaults for N and P excretion), Tier 2 with building block level 2 (country specific defaults for the building blocks of 'feed intake' and 'retention') and Tier 3 with building block level 3 (country specific measurements for most the sub-building blocks of 'feed intake' and 'retention').

per animal per year). The format of figure 3.1 is used in the next paragraphs to explain the building blocks of the calculation of the national and/or regional N and P excretion coefficients.

Figure 3.1 Building blocks for the calculation of N and P excretion coefficients (kg per animal per year)



3.2.2.1 Level 1

3.2.2.2 N and P excretion per animal

Calculated as: N or P intake (kg/year) – N or P retention (kg/year)

Building blocks (see level 2):
- N or P intake
  - Feed intake per animal (kg product or kg dry matter per year)
  - Feed composition (g N and g P per kg product or kg dry matter per feed)
- N or P retention
  - Growth, reproduction, milk, eggs and wool per animal (kg animal product)
  - Composition of growth, reproduction, milk, eggs and wool (g N and g P per kg animal product)

3.2.2.3 Level 2

3.2.2.4 Level 2 building block 1: N and P intake (kg N or P/year)

Calculated as: Feed intake (kg/year) x Feed composition (kg N or P/kg)

Building blocks (see level 3):
- Feed intake per animal or per animal category
- Feed composition per animal category

3.2.2.5 Level 2 building block 2: N and P retention (kg/year)

Calculated as: animal production (kg/year) x composition of animal production (kg N or P/kg)

Building blocks (see level 3):
- Animal production
- Composition of animal production

3.2.3 Level 3

3.2.3.1 Level 3 building block 1: Feed intake per animal or per animal category

Data origin (see level 4) for feed intake may have different sources:
- Defaults from common literature
- Specific defaults from country or region specific feed tables
- Calculated feed intake derived from registered animal production and feed requirements
- Annual registered feed intake
  - Country
  - Region
  - Farm
  - Animal
    - Individual
    - Category
    - Species

3.2.3.2 Level 3 building block 2: Feed composition per animal category

Data origin (see level 4) for feed composition may have different sources:
- Defaults from common literature
- Specific defaults from country or region specific feed tables
- Annual analyses of feeds and roughages

3.2.3.3 Level 3 building block 3: Animal production

Data origin (see level 4) for animal production may have different sources:
- Defaults from common literature
- Specific defaults from country or region specific data bases
- Annual registered animal production
  - Country
  - Region
  - Farm
  - Animal
    - Individual
    - Category
    - Species

3.2.3.4 Level 3 building block 4: Composition of animal production

Data origin (see level 4) for animal composition may have different sources:
- Defaults from common literature
- Specific defaults from country or region specific experiments

3.2.3.5 Level 4

Level 4 is the basic level of building blocks or the original input of data. The way data are collected (data origin) is a major factor affecting the quality of the calculated excretion coefficients. Therefore, data origin is described in a separate paragraph (see 3.3).

3.2.3.6 Volatilisation losses

Ammonia (NH_3) and nitrate (NO_3) nitrogen are susceptible to volatilisation losses, following transformation processes, which depend on environmental conditions. To calculate manure production, the N excretion *ex animal* has to be corrected for losses of ammonia and other volatile N components (corrections for gaseous N losses).

3.3 Data origin

To calculate N and P excretion on a national level several data origins can be distinguished. Table 3.1 shows five different data origins of decreasing quality (1 is the best). These five data origins could be combined with quality parameters as statistical reference and update interval. 'Statistical reference' is an abbreviation used for data that are based on a referred national inventory. The combination of 'update interval' and 'reference' can be scored as 1, 2, 3 and 4 for 'update interval' and Y(es) or N(o) for availability of a 'reference'. As an example table 3.1 presents various possibilities. The format and over-all score of table 3.1 is used for further analysis in paragraph 3.4.

Table 3.1 Data origin and data quality per country under consideration

Data origin	**Statistical reference**		**Update interval in years**				**Over-all**
			1	2-5	5-10	>10	**score**
	Yes	No					
1 Measurements input-output							
Animal[1)]	x		x				1Y1
farm[1)]	x			x			1Y2
region[1)]	x				x		1Y3
country[1)]	x					x	1Y4
2 Modelling approach							
animal[1)]	x		x				2Y1
farm[1)]	x			x			2Y2
region[1)]		X	x				2N1
country[1)]		X		x			2N2
3 Measurements manure							
animal category[1)]		X	x				3N1
animal species[1)]		X		x			3N2
farm[1)]		X			x		3N3
country[1)]		X				x	3N4
4 Defaults							
animal category[1)]	x			x			4Y2
animal species[1)]	x				x		4Y3
common literature[1)]		X		x			4N2
country specific information[1)]		X			x		4N3
5 Expert judgement							
animal category[1)]	x				x		5Y3
animal species[1)]	x					x	5Y4
common literature[1)]		X			x		5N3
country specific information[1)]		X				x	5Y4

[1)] Observational unit

3.4 Comparison of data origin and data quality

A quantitative comparison of data origin and data quality between countries is not possible, but a qualitative comparison is possible as described in paragraph 3.3. For the ten countries under consideration table 3.2 provides an overview.

Table 3.2 Overview of scored data quality codes for ten EU countries

Building block	Country									
	DK	**Fr**	**Ger**	**Irl**	**It**	**NL**	**UK**	**Esp**	**P**	**Est**
N intake	1Y1	2Y1	2Y2	2Y1	2Y3	1Y1	2Y1	2Y1	5N4	5N1
N deposition	2Y1	2Y1	2Y2	2Y1	2Y3	1Y1	2Y1	2Y1	5N3	5N3
Feed intake	1Y1	2Y1	2Y2	2Y1	1Y3	1Y1	2Y1	2Y1	4N3	5Y1
Feed composition	1Y1	2Y1	2Y2	2Y1	1Y3	1Y1	2Y1	1Y1	4N3	5N1
Animal production	2Y1	2Y1	2Y2	2Y1	2Y3	1Y1	2Y1	1Y1	4N3	3Y1
Animal composition	4Y1	1Y3	4Y2	4Y1	4N3	4Y2	4Y1	4Y2	4N3	5N3
Method used	B	B	B	B	B	B	B	B	SFOM	IPCC

Table 3.2 shows that 8 out of 10 countries under consideration use the balance method (B). These 8 countries apparently have the infrastructure to collect information of the building blocks of the balance method. Poland and Estonia rely on different methodologies for the calculation of excretions. As a result they have a lower score in the approach of table 3.2. The information from table 3.2 was subsequently translated in qualitative parameters (+/-) to enable quick insight in data origin and data quality (table 3.3).

Table 3.3 Qualitative overview of data origin and data quality for ten EU countries (+++ = best quality and --- = poorest quality).

Building block	Country									
	DK	**Fr**	**Ger**	**Irl**	**It**	**NL**	**UK**	**Esp**	**P**	**Est**
N intake	+++	++	++	++	+	+++	++	++	---	-
N deposition	++	++	++	++	+	+++	++	++	---	--
Feed intake	+++	++	++	++	++	+++	++	++	--	+/-
Feed composition	+++	++	++	++	++	+++	++	+++	--	-
Animal production	++	++	++	++	+	+++	++	+++	--	+
Animal composition	++	+++	+	++	-	+	++	+	--	---
Total	+	+	0	+	0	+	+	+	-	-
Method used	B	B	B	B	B	B	B	B	SFOM	IPCC

From table 3.3 it can be concluded that all countries that use the balance method have sufficient data quality to calculate accurate animal excretions, although differences occur. Poland and Estonia are not able to use the balance method, chose different methods and thus have to accept less quality and accuracy in calculating standard excretion coefficients.

3.5 Executive summary of country information

3.5.1 Introduction

The country reports (Chapters 4 -13) show a wide variation in excretion coefficients per animal category. This variation could be explained by two causes:
a) differences in the quality and accuracy of the calculations
b) differences between regions concerning animal husbandry system.

The former paragraphs allowed to make a qualitative comparison between countries for quality and accuracy of the calculated excretion coefficients. It was concluded that except for Poland and Estonia, all countries have sufficient data quality to calculate accurate country specific N and P excretions coefficients. This means, among others, that when comparing excretion coefficients between these countries, observed differences must be due to regional differences.

Regional differences may be the result of:
- Different diets (i.c. different availability of feedstuffs)
- Different animal breeds (i.c. different intake and different retention)
- Different production levels (i.c. milk production, slaughter weight, egg weight)

3.5.2 Cattle

Regional differences in N and P excretion coefficients for cattle are large among the 10 selected countries. There are large variations in available feeds (diets), breeds and production levels, but also in animal husbandry (housing- and feeding systems).

In paragraph 3.1 it was explained that data origin usually follows the dominant local husbandry system in animal categorization. Especially for ruminants large variation in animal categorization was observed. Since the impact of animal categorization has the same impact on N and P excretion coefficients, further analysis for grazing animals focuses on N excretion and the categories dairy cattle and beef cattle. Table 3.4 gives an overview of the N excretion coefficients (ex animal) for dairy and beef cattle. It clearly shows the large variation due to regional differences.
For dairy cattle some countries have excretion coefficients for the average animal regardless milk production level (Spain and Italy) and some countries have excretion coefficients for the average animal milk production level (Denmark, Ireland, United Kingdom and Poland). Other countries differentiate the excretion coefficients for dairy cattle according to milk production level, and type of diet (France and Germany) or for milk production and milk urea level (the Netherlands).
For beef cattle there seem to be less variety in animal categories than for dairy cattle, but still large differences are observed in excretion coefficients.
For both dairy cattle and beef cattle these differences are over-all well explained by regional differences.

Table 3.4 N excretion coefficients (ex animal) in different countries for cattle (kg/animal/year)

Category			Denmark	Estonia[1]	France[2]	Ireland	Italy	Germany[2]	Netherlands	Poland[1]	Spain	UK
Dairy	Milk (kg/yr)	weight (kg)		?			116		136.7		86.6	
	>5000					94,0			105.6	86.7		
	6000				80.4-134.4			100.8-119.5	114.5	86.7		116.7
	7000				88.4-147.8			114.9-131.7	125.2	119.3		
	8000				96.4-161.3			135.0-149.4	133.0	119.3		133.7
	9000		141.4		92.5-154.6				144.9	119.3		
	>10.000								160.4	119.3		
Beef		0-440	35.9		29.0							
		30-640			37.3	56.0	33.6		32.3	22.8	23.0	56.0
		45-625						35.3				
		45-700						40.1				

1) Not balance method, but system based on mineral excretion by manure.
2) Different excretion coefficients relate to well defined different diets

3.5.3 Pigs

In Tables 3.5 and 3.6, the N and P contents per category of pig (g/kg live weight) in different countries are shown.

Table 3.5 N contents per category of pig (g/kg live weight) in different countries

Category	Estimated Weight kg)	Age/Physio-logical state	Denmark	Estonia[2]	France	Ireland	Italy	Germany	Netherlands	Poland[2]	Spain	UK
Dead born piglet	1.3	0 days	[1]	?	?	?	?	25.6	18.7	?	?	?
Culled piglet	2.8	1 – 28 days	[1]	?	?	?	?	25.6	23.1	?	?	?
Culled piglet	9.0	29 – 42 days	[1]	?	?	?	?	25.6	24.3	?	?	?
Weaned piglet	7.0	4 weeks	30.4	?	18.3	30.4	?	25.6	?	?	?	30.4
Weaned piglet	11.0	6 weeks	30.4	?	18.3	25.0	?	25.6	24.4	?	?	25.0
Culled piglet	12.0	7 weeks	30.4	?	18.3	?	?	25.6	24.5	?	?	?
Growing pig	26	10 weeks	29.6	?	18.5	25.0	24.0	25.6	24.8	?	?	25.0
Finishing pig	114	26 weeks	29.6	?	18.5	25.0	24.0	25.6	25.0	?	?	25.0
Rearing sow	125	7 months	25.7	?	?	22.0	?	25.6	24.9	?	?	22.0
Rearing sow	140	First mating	25.7	?	?	22.0	?	25.6	24.9	?	?	22.0
Rearing boar	135	7 months	25.7	?	?	27.4	?	25.6	24.9	?	?	27.4
Boar (breeding)	325	2 years	25.7	?	?	27.4	?	25.6	25.0	?	?	27.4
Breeding sow	220	At weaning	25.7	?	?	25.6	?	25.6	25.0	?	?	25.6
Sow at slaughter	220	1 wk after weaning	25.7	?	?	25.6	?	25.6	25.0	?	?	25.6

[1]) is settled with the sows.
[2]) Not relevant, because system is based on mineral excretion by manure.

Table 3.6 P contents per category of pig (g/kg live weight) in different countries

Category	Estimated Weight (kg)	Age/Physio-logical state	Denmark	Estonia	France	Ireland	Italy	Germany	Netherlands	Poland	Spain	UK
Dead born piglet	1.3	0 days	[1]	?	?	?	?	5.1	6.15	?	?	?
Culled piglet	2.8	1 – 28 days	[1]	?	?	?	?	5.1	5.36	?	?	?
Culled piglet	9.0	29 – 42 days	4.9	?	?	?	?	5.1	5.35	?	?	?
Weaned piglet	11.0	6 weeks	4.9	?	4.0	5.0	?	5.1	5.33	?	?	5.0
Culled piglet	12.0	7 weeks	4.9	?	4.0	5.0	?	5.1	5.33	?	?	5.0
Growing pig	26	10 weeks	5.5	?	3.8	5.0	?	5.1	5.32	?	?	5.0
Finishing pig	114	26 weeks	5.5	?	3.8	5.0	?	5.1	5.36	?	?	5.0
Rearing sow	125	7 months	6.0	?	?	?	?	5.1	5.35	?	?	?
Rearing sow	140	First mating	6.0	?	?	?	?	5.1	5.35	?	?	?
Rearing boar	135	7 months	6.0	?	?	?	?	5.1	5.35	?	?	?
Boar (breeding)	325	2 years	6.0	?	?	?	?	5.1	5.35	?	?	?
Breeding sow	220	At weaning	6.0	?	?	?	?	5.1	5.35	?	?	?
Sow at slaughter	220	1 wk after weaning	6.0	?	?	?	?	5.1	5.35	?	?	?

[1]) is settled with the sows.

[2]) Not relevant, because system is based on mineral excretion by manure.

The N and P contents of the different categories of pig diets are provided in Tables 3.7 and 3.8.

Table 3.7 N contents per category of pig diets (g/kg) in different countries

<table>
<tr><th>Category</th><th>Denmark</th><th>Estonia</th><th>France</th><th>Germany[1]</th><th>Ireland</th><th>Italy</th><th>Netherlands</th><th>Poland</th><th>Spain[2]</th><th>UK</th></tr>
<tr><td>Starter diet weanling pigs</td><td rowspan="3">25.7</td><td>?</td><td>32.0-33.6</td><td>29.6</td><td>35.2</td><td rowspan="2">29.1</td><td>27.0</td><td>?</td><td>32.9</td><td>35.2</td></tr>
<tr><td>Grower diet weanling pigs (12-26 kg)</td><td>?</td><td>28.8-30.4</td><td>29.6</td><td>32.0</td><td>27.9</td><td>?</td><td>30.9</td><td>32.0</td></tr>
<tr><td>Starter diet growing finishing pigs (26–30 kg)</td><td>?</td><td>28.0</td><td>28.0-28.8</td><td>32.0</td><td rowspan="3">24.5</td><td>27.1</td><td>?</td><td>30.9</td><td>32.0</td></tr>
<tr><td>Grower diet growing finishing pigs (30–70 kg)</td><td rowspan="2">24.7</td><td>?</td><td>26.4</td><td>26.4 – 28.0</td><td>29.6</td><td>26.2</td><td>?</td><td>28.4</td><td>29.6</td></tr>
<tr><td>Finisher diet (70–114 kg)</td><td>?</td><td>24.0</td><td>22.4 – 23.2</td><td>27.2</td><td>23.6</td><td>?</td><td>26.7</td><td>27.2</td></tr>
<tr><td>Rearing sow diet (26–125 kg)</td><td>?</td><td>?</td><td>?</td><td>23.2 – 28.0</td><td>25.6</td><td>?</td><td>24.5</td><td>?</td><td>26.0-28.4</td><td>25.6</td></tr>
<tr><td>Standard sow diet</td><td rowspan="3">22.3</td><td>?</td><td>26.4</td><td>27.2</td><td>?</td><td rowspan="3">24.0</td><td>23.8</td><td>?</td><td rowspan="3">26.0-30.2</td><td>?</td></tr>
<tr><td>Lactating sow diet</td><td>?</td><td>26.4</td><td>28.0</td><td>27.2</td><td>24.5</td><td>?</td><td>27.2</td></tr>
<tr><td>Gestating sow diet</td><td>?</td><td>22.4</td><td>23.2</td><td>20.0</td><td>20.4</td><td>?</td><td>20.0</td></tr>
</table>

[1]) In Germany, standard and N-low diets are distinguished for growing finishing pigs and adjusted to growth rates of 700 or 800 g/d, resulting in ranges of N contents.
[2]) High value for in sow diets is related to high performing sows.

N contents of pig diets up to 30 kg are generally low in Denmark and the Netherlands, and rather high in Ireland/UK, whereas intermediate contents were reported in France, Germany, Italy and Spain. N-contents of pig diets from 30 kg to slaughter are low in Denmark, France, Germany (N-low diets), Italy and the Netherlands, and rather high in Ireland/UK and Spain. Danish sow diets contains the lowest N content, whereas the N content of sow diets are highest in Germany and Spain (high performing sows). The N contents of the sow diets in the other countries are in between.

Table 3.8 P contents per category of pig diets (g/kg) in different countries

Category	Denmark	Estonia	France	Germany	Ireland[1]	Italy	Netherlands	Poland	Spain	UK[1]
Starter diet weanling pigs	5.2	?	6.8-7.5	6.0	5.8-6.8	?	5.5	?	?	5.8-6.8
Grower diet weanling pigs (12-26 kg)		?	5.8-6.5	6.0	5.5-6.5	?	5.3	?	?	5.5-6.5
Starter diet growing finishing pigs (26–30 kg)		?	5.8	5.5	5.0-6.0	?	4.7	?	?	5.0-6.0
Grower diet growing finishing pigs (30–70 kg)	4.4	?	4.8	5.0-5.5	4.6-5.7	?	4.8	?	?	4.6-5.7
Finisher diet (70–114 kg)		?	4.4	4.5		?	4.6	?	?	
Rearing sow diet (26–125 kg)	5.0	?	?	5.0-6.0	5.5-6.5	?	5.0	?	?	5.5-6.5
Standard sow diet		?	6.5	6.0	?	?	5.4	?	?	?
Lactating sow diet		?	6.0	5.5	5.8-6.8	?	5.7	?	?	5.8-6.8
Gestating sow diet		?	5.0	4.5	5.5-6.5	?	5.0	?	?	5.5-6.5

[1]) In Germany, standard and P-low diets are distinguished for growing finishing pigs and adjusted to growth rates of 700 or 800 g/d, resulting in ranges of P contents.
[1]) Low value refers to diets with phytase and high values to diets without phytase.

P content of diets of pigs up to 30 kg are low in the Netherlands and Ireland/UK, whereas P content of these diets are intermediate in Germany, and high in France and diets without phytase in Ireland/UK. In case of P-low diets (by use of phytase) P content of pig diets from 30 kg onwards are comparable between countries. Without phytase addition, the P content increases with 0.5 (Germany) to 1.1 (Ireland/UK) g/kg. Likewise, in case of P-low diets P content of sow diets are comparable between countries. Without phytase addition, the P content increases with 1.0 g/kg (Ireland/UK).

In Germany, the N content of all categories of pigs is 25.6 g/kg (Table 3.5). For piglets and growing finishing pigs, this value is rather high compared to the values used in most of the other countries (France, Ireland, Italy, NL and UK). Values higher than 25.6 g/kg are used for 4-week old weaned piglets in Denmark and Ireland (30.4 g/kg) and boars in Ireland (27.4 g/kg) and growing finishing pigs in Denmark (29.6 g/kg).
For breeding sows, the 25.6 g/kg is also used in Ireland, the UK and Denmark (25.7 g/kg). Ireland, NL and the UK are using comparable values (24.8 – 25.0 g/kg) for the category of growing finishing pigs. In Italy, a little lower value (24.0 g/kg) is used for this type of pigs, whereas the value used in France (18.5 g/kg) is really out of range. The rather low N content in Italian growing finishing pigs might be related to a high fat

content, because of the high slaughter weight (163.4 kg) of the Italian pigs. No explanation for the low N content in French growing finishing pigs is available.

In Germany, the P content of all categories of pigs is 5.1 g/kg (Table 3.6). In Ireland and the UK, comparable P contents (5.0 – 5.1 g/kg) are used for piglets and growing finishing pigs. In the Netherlands, the P content of all categories of pigs are in narrow range of 5.32 – 5.36 g/kg, accept for dead born piglets (6.15 g/kg). The P contents of pigs in Denmark ranged from 4.9 g/kg in weaned pigs to 6.0 g/kg in sows and boars. Compared to the contents in other countries, the Danish P contents for growing finishing pigs and breeding animals are high. In contrast, the French P contents for weaned piglets (4.0 g/kg) and growing finishing pigs (3.8 g/kg) are really out of range. No explanation for these low values is available.

The N and P excretion coefficients for pigs (ex animal) in different counties (kg/animal/year) are shown in Table 3.9 and 3.10, respectively.

Table 3.9 N excretion coefficients for pigs (ex animal) in different counties (kg/animal/year)

Category	Denmark	Estonia	France[3]	Germany[4]	Ireland	Italy	Netherlands	Poland	Spain	UK
Average present sow incl. piglets to weaning	26.4[1]		20.4 – 24.6		20.1		20.9		20.44	20.1
Average present sow incl. piglets up to the grower period				34.9–37.3		36.6	29.1	37.20	26.22	
Weaned piglets	0.53[2]	5.2	0.56–0.62[2]	3.3 – 3.4	6.5		3.38	6.69	1.71	6.5
Growing–finishing pig	3.1[2]		3.8–4.6[2]	11.2-13.6[5]	10.9[6]	13.81	10.9	29.52	7.69	10.9[6]

[1]) Based on a performance level of 26.0 weaned piglets (7.3 kg) per sow per year.
[2]) Animal basis
[3]) First value is based on a 2-phase feeding system; the second value is based on a standard feeding system.
[4]) Based on a performance level of 22.0 weaned piglets (28 kg) per sow per year. The first value is based on N/P low diets, the second value is based on standard diets.
[5]) Based on growth rate of 800 g/d.
[6]) Range of 25 – 100 kg BW.

Table 3.10 P excretion coefficients for pigs (ex animal) in different counties (kg/animal/year). Phosphate excretion coefficients between brackets

Category	Denmark	Estonia	France[3]	Germany[4]	Ireland	Italy	Netherlands	Poland	Spain[2]	UK
Average present sow incl. piglets to weaning	5.7[1] (13.1)		4.8 – 6.11 (11.0–14.0)		5.83 (13.35)		5.02 (11.50)			5.83 (13.35)
Average present sow incl. piglets up to the grower period				6.8-8.1 (15.6-18.6)			6.43 (14.72)			
Weaned piglets (7.3 – 32 kg)	0.14[2] (0.32)		0.11 – 0.14 (0.25–0.32)	0.63-0.71 (1.44-1.63)	0.94 (2.15)		0.57 (1.31)			0.94 (2.15)
Growing–finishing pig (32 – 112 kg)	0.54[2] (1.23)		0.63 – 0.92 (1.44–2.11)	2.1-2.6[5] (4.8-6.0)	1.71 (3.92)		1.88 (4.31)			1.71 (3.92)

[1]) Based on a performance level of 26.0 weaned piglets (7.3 kg) per sow per year.
[2]) On an animal basis.
[3]) First value is based on a 2-phase feeding system; the second value is based on a standard feeding system.
[4]) Based on a performance level of 22.0 weaned piglets (28 kg) per sow per year. The first value is based on N/P low diets, the second value is based on standard diets.
[5]) Based on growth rate of 800 g/d.
[6]) Range of 25 – 100 kg BW.

Ireland, the Netherlands and the UK have comparable N excretion coefficients for pigs. Denmark has a relatively high excretion coefficient for sows including piglets to weaning, which might be explained by the high performance level of the Danish sows, as well as by the relatively high N contents in the different pig categories. The French sows show a range of N-excretion, depending on the a standard or 2-phase feeding system. Compared to the other countries, the N-excretion of Spanish weaned piglets and growing-finishing pigs is low. No explanation is found for it. On the other hand, the N-excretion of Polish growing-finishing pigs is about 300% higher compared to the other countries. This value for N-excretion seems to be an artefact.

The variation in P-excretion coefficients between countries is relatively low. The relatively high level of P-excretion in German sows seems to be related to the high feed consumption of these animals. The P-content of the Irish and UK pig diets is relatively high, as well as the P-content of the Danish pigs, resulting in slightly higher P-excretion coefficients of pigs in those countries.

3.5.4 Poultry

The N and P excretion coefficients for broilers and laying hens (ex animal) in different counties (kg/animal/year) are shown in Table 3.11 and 3.12, respectively.

Table 3.11 N excretion coefficients for poultry (ex animal) in different counties (kg/animal/year)

Category	Denmark	Estonia	France	Germany[1]	Ireland	Italy	Netherlands	Poland	Spain	UK
Broiler chickens, 30 days	0.317									
Broiler chickens, 32 days	0.346			0.34-0.39						
Broiler chickens, 35 days	0.395									
Broiler chickens, 40 days	0.478			0.40-0.47	0.429	0.36	0.498	0.262	0.34	0.429
Broiler chickens, 45 days	0.563		0.051[2]							
Barn-reared chickens, 56 days[1]	0.351		0.068[2]							
Broiler chickens organic, 81 days[1]	0.508		0.125[2]							
Laying hens, free-range	0.875		0.703		0.830				0.39	0.830
Laying hens, organic	1.010		0.718							
Laying hens, barn-reared	0.864									
Laying hens, cages	0.684		0.713	0.754	0.720	0.66-0.85[3]	0.726	0.382	0.42	0.720

[1]) The first value is based on N/P low diets, the second value is based on standard diets.
[2]) On an animal basis.
[3]) Variation due to different strains.

Table 3.12 P excretion coefficients for poultry (ex animal) in different counties (kg/animal/year). Phosphate excretion between Brackets.

Category	Denmark	Estonia	France	Germany	Ireland[3]	Italy	Netherlands	Poland	Spain	UK
Broiler chickens, 30 days[1]	0.036 (0.082)									
Broiler chickens, 32 days[1]	0.039 (0.090)			0.07-0.09 (0.16-0.21)						
Broiler chickens, 35 days[1]	0.045 (0.103)									
Broiler chickens, 40 days[1]	0.057 (0.130)			0.08-0.11 (0.18-0.25)	0.10-0.13 (0.22-0.29)		0.075 (0.172)			0.10-0.13 (0.22-0.29)
Broiler chickens, 45 days[1]	0.072 (0.164)		0.011 (0.025)[2]							
Barn-reared chickens, 56 days[1]	0.122 (0.278)		0.017 (0.038)[2]							
Broiler chickens organic, 81 days[1]	0.135 (0.310)		0.030 (0.069)[2]							
Laying hens, free-range	0.181 (0.414)		0.136 (0.311)		0.17-0.22 (0.39-0.49)					0.17-0.22 (0.39-0.49)
Laying hens, organic	0.228 (0.522)		0.133 (0.304)							
Laying hens, barn-reared	0.178 (0.408)									
Laying hens, cages	0.155 (0.355)		0.134 (0.307)	0.148 (0.339)	0.16-0.20 (0.36-0.46)		0.172 (0.394)			0.16-0.20 (0.36-0.46)

[1]) The first value is based on N/P low diets, the second value is based on standard diets.
[2]) On an animal basis.
[3]) The first value is based on diets with addition of microbial phytase; the second value is based on diets without microbial phytase addition.

The N-excretion levels of broilers and laying hens are comparable for most of the countries, except for Poland and Spain, that have much lower N-excretion levels for both species. No explanation for these difference were found.

P-excretion levels of broilers and laying hens show some variation, depending on whether or not the use of microbial phytase, the strain and the length of the growing period.

3.6 Conclusions

The balance method is the best method available to estimate N and P excretion coefficients at higher aggregation levels than individual animals or small animal groups. However, the accuracy and quality of the calculated excretion coefficients depends on the quality of the data used (data origin). To enable review of the quality of excretion coefficients, it is necessary to document data origin for all building blocks of the balance method. For the 10 countries under consideration, 8 used the balance method and provided accessible documentation of data origin. Although differences were observed in data origin of these 8 countries, they all estimate N and P excretion coefficients with sufficient accuracy and quality.

Comparing excretion coefficients between countries is difficult. Even between countries that use the balance method. Differences in N and P excretion coefficients may be well explained by regional differences in animal husbandry systems. Moreover, even when regional differences are not present or fully accounted for, comparison may be disturbed by differences in animal categorization. Individual countries usually base their animal categorization on the availability of good quality data which is closely related to the dominant local animal husbandry systems. Uniform animal categorization may bring more clarity in country comparisons, but on the other hand may negatively affect accuracy and quality of the estimated N and P excretion coefficients. This becomes relevant when uniform animal categorization significantly differs from local categorization meaning that data origin is not adapted and has to be transformed to the new categories.

National N and P excretion can accurately be estimated by the balance method as the sum of the excretion of all distinguished animal categories. The excretion per animal category is calculated as the result of the balance method for excretion multiplied by the animal numbers in that category. However, when reporting the N and P excretion to the EU, Member States do not use the direct results of the balance method. It seems that Member States use default excretion coefficients and uniform animal categories. It is not clear if and how the default excretion coefficients are established, but preferably they should be a reflection of the balance method approach. To facilitate a common method for EU-27 countries, based on the results of the balance method, the following is proposed:

Input
- Uniform animal categories
- Country specific defaults for N and P excretion coefficients per uniform animal category

Calculations
- Country specific default excretion coefficients per uniform animal category
    a) Calculate the national N and P excretion by the balance method using local animal categories.
    b) Use the specific excretion coefficients of a) to estimate draft default excretion coefficients for the uniform animal categories.
    c) Calculate the national N and P excretion using the draft default excretion coefficients of b) in combination with the uniform animal categories.
    d) The results of a) and c) should be equal, but when differences occur specific correction factors for the draft default excretion coefficients of b) should be derived to overcome the differences and calculate final default excretion coefficients.
    e) EU reviews the calculation process (steps a to d) and verifies the country specific default excretion coefficients per uniform animal category

Update of final default country specific excretion factors

The update of default excretion factors follows the country specific update of data, which could be yearly but also longer intervals.

4 Denmark

4.1 Methodology

Nitrogen excretion data of livestock operations which are being used in Denmark have been extracted from the "Guidelines on fertilization and harmony rules; plan period 1 August 2008 to 31 July 2009", which were compiled by the Danish Ministry for Food, Agriculture and Fisheries in July 2012 and from the "Danish Emission Inventory for Agriculture; Inventories 1985 – 2009" (Mikkelsen et al, 2011). In these publications, default values for nitrogen and phosphorus intake and retention for livestock have been published, from which N and P excretion and N and P content in manure have been determined by balance method.

4.2 Animal categories

The animal categories used in Denmark are presented in Table 4.1

Table 4.1 Animal categories

Species	Category	Description	Excretion Ex animal kg/hd/yr	
			N	P
Cattle	Lactating cow of large breed	Dairy cow of FH or similar breed and producing on average 9,265 kg of milk per year (2012)	141.4	20.1
	Lactating cow of Jersey breed	Dairy cow of Jersey breed and producing on average 6,584 kg of milk per year (2012)	119.8	17.7
	Replacement heifer 0-6 mo Large breeds	Young female animal reared to replace less-productive dairy cows, age between 0 and 6 months	26.7	2.96
	Replacement heifer 0-6 mo Jersey	Young female animal reared to replace less-productive dairy cows, age between 0 and 6 months	20.0	2.22
	Replacement heifer 6-27 mo Large breeds	Young female animal reared to replace less-productive dairy cows, age between 6 months until first partus at an age of 27 months	50.4	6.57
	Replacement heifer 6-27 mo Jersey	Young female animal reared to replace less-productive dairy cows, age between 6 months until first partus at an age of 25 months	37.9	4.95
	Steers of large breed 0-6 mo	Young male animal	11.6	1.2
	Steers of Jersey breed 0-6 mo	Young male animal	8.5	0.92
	Fattening cattle large breed	Non-lactating cattle fattened from 6 months until slaughter at 440 kg	24.3	3.79
	Fattening cattle Jersey breed	Non-lactating cattle fattened from 6 months until slaughter at 328 kg	18.9	2.91
	Non-lactating cow <400 kg	Non-lactating dairy cow, weighing less than 400	43.6	4.14
	Non-lactating cow 400-600 kg	Non-lactating dairy cow, weighing between 400 and 600 kg	63.6	6.06
	Non-lactating cow >600 kg	Non-lactating dairy cow, weighing more than 600 kg	72.4	6.91

4.3 Data origin

The "Guidelines on fertilization and harmony rules; plan period 1 August 2008 to 31 July 2009" (Mikkelsen et al, 2011) provides no direct data of nitrogen and phosphorus excretion by various livestock categories, but provides data on feed intake, protein and phosphorus content in feed and production as milk, growth or eggs. For dairy cattle, data on milk yield and milk protein content are based on statistical information published by the Danish Cattle Federation (2009).

4.3.1 Grazing animals

4.3.1.1 Dairy cows

Nitrogen and phosphorus balances for lactating dairy cows are calculated based on annual statistics of Danish dairy production and presuming a nitrogen retention of 173 for large breeds and 108 kg N per animal per year for Jersey breeds. Balances are estimated for dairy cows of large breeds and for dairy cows of Jersey breeds. Feed composition is similar for both categories of dairy cattle. Data are presented in Table 4.2.

Table 4.2. Nitrogen excretion of lactating dairy cows

Item	Unity	Large breed	Jersey cows
N applied to land[1]	kg/hd/yr	123.6 - 147.3	104.7 – 124.5
N balance			
Intake	kg /head/yr	192.2	163.5
Milk secretion	Kg/head/yr	49.1	42.6
Retention	kg/head/yr	1.7	1.1
Excretion	kg/head/yr	141.4	119.8
Basic data			
Feed intake	Feed units/hd/yr	6944	5907
Feed crude protein	kg/FE	0.173	0.173
Feed phosphorus	kg/FE	0.00425	0.00425
Milk yield	kg/ kg/hd/yr kg	9265	6584
Milk protein content	kg/kg	0.0338	0.0413
Milk phosphorus content	Kg/kg	0.00096	0.00108

[1]N applied to land (ex store) varies with type of housing

4.3.2 igs

Table 4.3 provides the N and P contents in different categories of pigs (The Danish Plant Directorate, 2009).

Table 4.3 The N and P contents (g/kg live weight) in different categories of pigs in Denmark (The Danish Plant Directorate, 2009)

Category	Estimated weight (kg)	Age/ Physiological state	N-content (g/kg)	P-content (g/kg)
Young pigs	7.3 – 32 kg	?	30.4	4.9
Growing -Finishing pig	32 – 107 kg	?	29.6	5.5
Sows including piglets up to 7.3 kg			25.7	6.0

The N and P contents of the different categories of pig diets are provided in Table 4.4.

Table 4.4 N and P contents (g/kg) in different categories of pig diets (The Danish Plant Directorate, 2009)

Category	N-content	P-content
Young pigs 7.3 – 32 kg	25.7	5.2
Pigs for slaughter 32 – 107 kg	24.7	4.4
Sow diet including piglets up to 7.3 kg	22.3	5.0

Table 4.5 provides the N and P balance for the different pig categories.

Table 4.5 N and P balance for the different pig categories on an annual base (The Danish Plant Directorate, 2009)

Category	Feed intake (kg)	N intake (kg)	P intake (kg)	N deposition (kg)	P deposition (kg)	N excretion (kg)	P excretion (kg)[1]
Average present sow incl. piglets (7.3 kg) housed in stalls[2]	1490	33.3	7.5	6.9	1.5	26.4	5.7 (13.1)
Average present sow incl. piglets (7.3 kg) housed outdoors[2]	1620	36.2	8.1	6.9	1.5	29.3	6.4 (14.6)
Weaned piglets (7.3 – 32 kg), animal basis	50	1.29	0.26	0.76	0.12	0.53	0.14 (0.32)
Growing–finishing pig (32 – 112 kg), animal basis	215	5.3	0.95	2.2	0.41	3.1	0.54 (1.23)

[1]) Phosphate excretion between brackets.

[2]) Based on a performance level of 26.0 weaned piglets per sow per year.

4.3.3 Poultry

Table 4.6 provides the N and P contents (g/kg live weight) in different categories of poultry (The Danish Plant Directorate, 2009).

Table 4.6 N and P contents (g/kg live weight) in different categories of poultry (The Danish Plant Directorate, 2009)

Category	Weight (g)	Age/ Physiological state	N-content (g/kg)	P-content (g/kg)
Poultry	All categories	All states	28.8	6.7
Eggs	All categories		18.1	2.0

The N and P contents of the different categories of poultry diets are provided in Table 4.7.

Table 4.7 N and P contents (g/kg diet) in different categories of poultry (The Danish Plant Directorate, 2009)

Category	N-content diet	P-content diet
Broiler chickens, 30 days	33.1	6.0
Broiler chickens, 32 days	32.8	5.9
Broiler chickens, 35 days	32.5	5.8
Broiler chickens, 40 days	32.0	5.7
Broiler chickens, 45 days	31.7	5.7
Barn-reared chickens, 56 days	24.0	6.9
Broiler chickens organic, 81 days	27.0	6.9
Laying hens, free-range	26.1	4.7
Laying hens, organic	28.8	5.7
Laying hens, barn-reared	26.1	4.7
Laying hens, cages	26.2	4.9
Broiler Breeders	24.5	5.2
Pullets (human consumption)	26.4	7.0
Rearing hens	25.6	6.0

Table 4.8 provides the N and P balance for the different poultry categories.

Table 4.8 N and P balance for the different poultry categories on a year base (The Danish Plant Directorate, 2009)

Category	Feed intake (kg)	N intake (kg)	P intake (kg)	N deposition (kg)	P deposition (kg)	N excretion (kg)	P excretion (kg)[2]
Broiler chickens, 30 days[1]	22.1	0.732	0.133	0.415	0.097	0.317	0.036 (0.082)
Broiler chickens, 32 days[1]	23.9	0.784	0.141	0.438	0.102	0.346	0.039 (0.090)
Broiler chickens, 35 days[1]	26.7	0.868	0.155	0.473	0.110	0.395	0.045 (0.103)
Broiler chickens, 40 days[1]	31.2	0.998	0.178	0.520	0.121	0.478	0.057 (0.130)
Broiler chickens, 45 days[1]	35.4	1.122	0.202	0.559	0.130	0.563	0.072 (0.164)
Barn-reared chickens, 56 days[1]	30.5	0.732	0.210	0.381	0.088	0.351	0.122 (0.278)
Broiler chickens organic, 81 days[1]	28.0	0.756	0.193	0.248	0.058	0.508	0.135 (0.310)
Laying hens, free-range	47.4	1.237	0.223	0.362	0.042	0.875	0.181 (0.414)
Laying hens, organic	47.3	1.362	0.270	0.352	0.042	1.010	0.228 (0.522)
Laying hens, barn-reared	47.1	1.229	0.221	0.365	0.043	0.864	0.178 (0.408)
Laying hens, cages	40.7	1.066	0.199	0.382	0.044	0.684	0.155 (0.355)
Broiler Breeders	53.9	1.321	0.280	0.263	0.034	1.058	0.246 (0.563)
Pullets (human consumption)	5.8	0.153	0.041	0.039	0.009	0.114	0.032 (0.073)
Rearing hens	7.5	0.192	0.045	0.049	0.011	0.143	0.034 (0.078)

[1]) Data were provided per cycle. For calculation on an annual base, a cleaning interval of 10 days was assumed.
[2]) Phosphate excretion between brackets.

4.4 Assessment

4.4.1 Complexity of methodology

The Danish normative system for manure excretion as described by the Danish Environmental Protection Agency (2013)
The values (ex storage) in the Danish normative system are used for fertilizer planning and control by the Danish farmers and authorities. In addition, the values (ex storage) are used when it comes to defining the Danish Livestock Unit (LU). The system is based on input and output. The values for nutrient content in manure are calculated in three steps (i) ex animal, (ii) ex housing and (iii) ex storage.

The normative system includes nutrients content (N,P and K) together with volume and dry matter content. Calculation of standard values for ex animal is the difference between input and output. Input is based on records and calculations of feed intake for the different categories combined with values on nutrient concentrations in the diets. The nutrient retention in the animal is calculated based on standard values obtained from the published literature and then subtracted. The excretion separated into faecal and urinary fractions is also calculated using the digestibility coefficients of the different nutrients. In the calculation for ex housing is included the different housing systems where the N loss due to emissions are included for each system based on results from experimental studies and qualified assumptions. Hereafter the contribution of nutrients from bedding materials are added and the soaking of urine into the bedding materials and faeces is calculated in order to establish values for slurry (faeces and urine together) and separately for faeces (manure or deep litter) and urine (liquid manure). Based on ex housing standards, the final step – ex storage - takes into consideration what happens while the different manures are stored. Losses of N (due to emissions) and dry matter are subtracted. Furthermore, redistributed nutrients, dry matter and liquid due to leakage of juice from faeces etc. are included in the model.

Values are calculated for all species and categories and relevant housing systems and manure types. For each type of livestock it is important that the standards for nutrient excretion are based on the actual average practice following data from a number of representative farms. This data can be feeding plans or national feed controlling systems in combination with production results, where feed utilization and nutrient excretion can be calculated from data of the amount and composition of feed used and sold products.

The definition of the livestock type has been changed over the years ending up with a system easier to control. For meat producing livestock as beef calf, feeding pigs and broilers it has shown useful to define the standards on e.g. nutrient excretion for a certain number of produced livestock, as the amount of sold meat can be controlled for both weight and numbers, in the farms tax account or from the balance from the slaughterhouse. The Danish standard values are updated annually and are to a large extent based on data from the Danish livestock production (practical farming) but do also include a few theoretical data. These default values are used by all farmers, but the system also includes possibilities for correction of the standards if the farmer can document own values on e.g. diet N content, productivity and yield.

Manure in the fertilizer account
The farmer must once a year submit a fertilizer account; this includes a calculation of the manure production for the farm holding. All husbandries (except horses) must be registered in

the Central Husbandry Register (CHR), with information about location, owner, type of animal and the current number of animals on the farm. In the fertilizer account the farm holding has to give information about the housing system and number of produced animals for the reporting period (plan period), and weight (in/out) or days at the farm. By using standardized norms for nitrogen in manure, the production of nitrogen from manure is calculated and when entering the number of livestock in the fertilizer account, the farmer's production of manure is automatically entered into the account. This is the amount of nitrogen in manure the farmer is obliged to account for.

Manure streams
The use of manure must be accounted for in the fertilizer account. If manure is delivered to another farm holding, it must be reported in the account, giving information about the central registration number of the farm holding, location, type, utilization per cent and the amount of manure (kg N and LU). It is only allowed to deliver manure to a farm holding, which is covered by the law on fertilizer and plant cover. This is part of the validation that takes place if the fertilizer account is submitted using the electronic submitting system. Otherwise it will be caught in the electronic control and cannot be submitted. The farm holding that receives manure must likewise account for the received manure. The Danish AgriFish Agency has a Register for all plants that receive and sell manure (processed or bio gassed). They are all obliged to report received and transferred manure yearly (before 1st of September).

Data gathering and nitrogen balance

Fertilizer plan
All farm holdings that are covered by the law on fertilizer and plant cover are yearly obliged to make a plan for all fields, that shows the use of nitrogen in fertilizer and manure, and calculate a nitrogen quota based on the standard nitrogen norms for crops. For each individual farm holding the allowed fertilizer use is based on the types of soil and on crops grown. Every type of crop and soil has a fertilizer application standard, which is the economically optimal dosage, as determined by research, minus at least 10 %. The calculation also includes nitrogen supply from previous crops on the field and precipitation, as this also determines the nitrogen content in the field.

Fertilizer account
The farmer must account for actual use at the end of the season by reporting the fertilizer account to the Danish AgriFish Agency: 1) how much nitrogen in manure or fertilizer has been bought, produced and received and 2) how much has been sold, stored or transferred to another farm. The difference between the two is recorded as nitrogen used on the fields, and this amount must not exceed the farm holding nitrogen quota. The information in the fertilizer accounts is also used to monitor violations of the harmony rules and rules concerning catch crops.

Businesses or persons which sell fertilizers (including plants where manure is processed and bio gassed) are obliged to control whether the buyer is registered as a "user of manure and fertilizer" in the national register and has to report the sale in kg N to the Danish AgriFish Agency. Information about purchased fertilizer and received manure (incl. processed and bio gassed manure) is pre-printed in the fertilizer account.

If the farm holding has applied for single payment by using the internet, information about summarized field size, catch crops - and in some cases - also the calculated nitrogen quota, are transferred to the system where the farmer must submit the fertilizer account and are pre-printed in the fertilizer account.

Registration of manure production

A part of the fertilizer account is a calculation of the manure production for the farm holding. Information from the Central Husbandry Register is transferred to the fertilizer account system, showing information about number of cows, cattle (and the number of days at the farm holding) etc. in the planning period.

In the fertilizer account the farm holding has to give information about the stable system and number of produced animals for the reporting period (plan period), and weight (in/out) or days at the farm. By using standardized norms for nitrogen in manure, the production of nitrogen from manure is calculated. If manure is delivered to another farm holding, it must be reported in the account, giving information about the central registration number of the farm holding, location, type, utilization percent and the amount of manure (kg N and LU). It is only allowed to deliver manure to a farm holding, which is covered by the law on fertilizer and plant cover. Otherwise it will be caught in the electronic control and cannot be submitted. The farm holding that receives manure, must likewise account for the received manure.

The fertilizer account can be submitted electronically and in special situations by paper. If the farmer uses the electronic submitting system, the account will be validated in the process. Hereby the farmer avoids sending accounts that don't make sense. 94% of the farmers submit the account electronically, which gives data a high quality. Accounts that are submitted by paper are typed manually into the file processing system.

4.4.2 Strength and weakness

Denmark is strong in method used and data origin. The quality and accuracy of the calculated excretion coefficients is good. Although there are no weaknesses a remark about animal categories could be made.

In Denmark, one combined category is used for breeding sows including piglets up to 7.3 kg, based on a performance level of 26 weaned piglets per sow per year. In some other countries, sub categories of breeding sows, e.g. rearing sows, boars, gestating sows and lactating sows, are distinguished. By use of different categories, the N and P excretion of breeding pigs might be estimated more precisely.

In Denmark, N and P contents in poultry carcasses are supposed to be similar for all kind of poultry categories. In other countries, different values for the distinguished categories are used. Likewise, N and P contents of broiler breeder eggs in Denmark are supposed to be similar to the contents in table eggs. Taking specific values per category into account might improve the accuracy of the national N and P excretion from poultry.

5 Estonia

5.1 Methodology

The Estonian methodology for calculation of the nitrogen excretion is based on the Revised 1996 IPCC Guidelines (IPCC, 1997). Excretions are not calculated according to a balance approach, but on manure amount and contents. For the Estonian way of calculation, the following data are required:

- Feed digestibility coefficients (%)
- Feed intake levels
- Amount of produced manure per animal/year
- N content of manure

5.2 Animal categories

Animal categories are cattle (dairy, fattening and rearing), pigs (piglets, young pigs, fattening pigs, breeding pigs), hens, horse and sheep.

5.3 Data origin

5.3.1 Grazing animals

Table 5.1 provides information on manure production (quantity and chemical composition) for different animal categories. These Estonian standards for calculation of the national N and P excretion are still under revision.

5.3.2 Pigs

The excretion standards for three pig categories are summarized in Table 5.1. Table 5.2 provides the N balance for the different pig categories (National Inventory Report Estonia, 2011).

Table 5.2 N balance for the different pig categories (National Inventory Report Estonia, 2011).

Category	Average weight (kg)	Feed intake (kg/year)	Feed digestibility (%)	Manure (kg/animal/ year)	N Content manure (g/kg)	N excretion (kg)
Piglets (< 20 kg)	10	183	0.75	474	10.9	5.2
Young pigs (20 - <50 kg)	35	365	0.75	1044	10.9	11.4
Growing-finishing pigs (50 –<80 kg)	65	548	0.75	1543	12.5	19.3
Growing–finishing pigs (80 –<110 kg)	95	694	0.75	1959	12.5	24.5
Growing-finishing pigs (=>110 kg)	110	767	0.75	2149	12.5	26.9
Breeding pigs (=> 50 kg)	75	584	0.75	1688	8.8	14.9

5.3.3 Poultry

For poultry, an average value of 0.6 kg N/animal/year is used (National Inventory Report Estonia, 2011).

Table 5.1 Manure production and chemical composition per animal per year (ex animal)

No	Animal species or age croup	Manure production and chemical composition								Remarks
		Quantity t/year	DM %	N kg	P kg	K kg	N kg/t	P kg/t	K kg/t	
1	Dairy cows	22,9	15,3	134,0	30,1	101,0	5,9	1,3	4,4	Average production 8725 kg milk and 270,4 kg milk protein per year
2	Suckler cows, beef cattle (>24 months)	8,3	14,9	72,4	6,9	72,5	8,7	0,8	8,7	
3	Cow calves (0…6 months)	2,6	12,3	17,1	2,1	17,1	6,7	0,8	6,7	
4	Bull calves (0…6 months)	2,4	12,5	13,9	1,3	8,9	5,9	0,6	3,8	
5	Heifers (6 months…calving)	11,4	13,9	58,1	11,1	48,7	5,1	1,0	4,3	
6	Bullock (6 months…realisation)	6,7	17,0	41,3	6,8	24,8	6,2	1,0	3,7	
7	Slaughter pigs	0,5	7,2	3,3	0,6	1,3	7,0	1,2	2,8	30-110 kg
8	Weaners	0,07	5,0	0,7	0,1	0,2	9,5	0,9	3,5	7-30 kg
9	Sow with piglets	4,0	9,5	25,1	5,4	10,1	6,3	1,4	2,5	Gestation period 70%, lactation period 30% per year, Weaning 28 days
10	Layers (100 birds)	4,4	12,0	69,3	15,6	25,5	15,7	3,5	5,8	Laying period 11-13 months
11	Broilers (1000 birds)	3,7	12,0	64,8	16,2	28,0	17,5	4,4	7,6	Rearing period 40 days
12	Young birds (100 birds)	0,6	12,0	11,7	3,2	3,4	19,8	5,5	5,8	Age to 140 days
13	Sheep	2,3	16,0	16,9	2,8	29,3	7,4	1,2	12,8	
14	Goat	2,2	16,0	17,0	2,9	19,5	7,6	1,3	8,7	
15	Horse	4,4	16,0	50,0	8,0	46,0	11,4	1,8	10,5	Body weight 500-700 kg
16	Fox	0,5	14,0	12,9	2,3	1,3	28,7	5,2	2,8	Breeding animal
17	Mink	0,2	14,0	5,6	1,0	0,5	23,5	4,2	2,0	Breeding animal

5.4 Assessment

5.4.1 Complexity of methodology

The method used in Estonia to calculate N excretion is not based on a balance approach, and therefore differs largely from that of many other European countries. The most important parameters of the Estonian method (Code of good Agricultural Practice Estonia) are the N content of manure and the manure production per animal on an annual base as described by the Danish Environmental Protection Agency (2013), *Conditions for the calculation and control of manure excretion.*

The Nitrate directive is implemented into the Water Act, which allows using 170 kg of total nitrogen per hectare of arable land in the average from manure. All farmers must keep a field book with fertilization data included. The overall control over the usage of manure is the task of the Environmental Inspectorate. Government agency Statistics Estonia (2013) calculates the usage of manure from data collected by sample survey and expands to the utilized agricultural area (UAA).

On the other hand, farmers can voluntary join with agri-environment support measures of the Rural Development Program (RDP, 2007-2013). In this case, the applicant must follow in its entire holding the cross-compliance requirements and the minimum requirements for the use of fertilizers and plant protection products. In 2010 the area covered with agri-environment support made 56% from UAA. Some requirements of manure using and control of applied plant nutrients are intended for the applicants. Therefore, over the half of UAA is under control.

Each applicant must:
- keep a field book;
- take manure samples – if more than 10 LU are kept in the enterprise, the applicant must organise the sending of manure samples to an accredited laboratory for the determination of dry weight, total N, ammonium nitrate and nitrate content of manure once within the commitment period;
- prepare a fertilization plan which will include information about the planned fertilization in each year.

In the fertilization plan, the applicant must prepare commercial and organic fertilizer account and estimate plant nutrient (N, P, K) consumption. The amount of plant nutrients applied with manure is calculated on the base of manure analysis data or standards, which are available in Good Agricultural Practice and in legislative acts of Ministry of Agriculture. Manure standards are under adjustment just now (Table 5.2).

The Estonian Agricultural Register and the Information Board (ARIB) controls the compliance of applicants and in case of non-compliance with baseline requirements, the ARIB will reduce support payments pursuant to procedure prescribed by national legislation and according to reduction rates.

Data gathering and calculation of nitrogen balance.
According to the Official Statistics Act, statistical data in Estonia are collected by the Statistics Estonia. Statistics Estonia started the nitrogen balance calculation since 2011. Farmers are obliged to forward data regarding plant production and animal husbandry input and output once a year. Collected data is used to calculate nitrogen balance for Estonia. Statistics Estonia uses the Nitrogen gross balance calculation methodology provided by the OECD and Eurostat (2007).

The gross balance is calculated as total nitrogen inputs minus total nitrogen outputs. The main elements in the gross nitrogen balance calculation are:
Total nitrogen inputs: (a) inorganic nitrogen fertilisers, (b) livestock manure, (c) biological nitrogen fixation, (d) atmospheric deposition of nitrogen compounds, and (e) other inputs (seeds and planting material).

Total nitrogen outputs: (a) total harvested crops (cereals, oilseeds, dried, pulses, root crops, total fruits, total vegetables), and (b) total fodder crops (plants harvested green, temporary grasses and grazing consumption, total of permanent grassland (pastures and meadows) consumption.
Data about production and consumption of fodder crops are not generally available, as is an exact overview of the amount of different species in the yield. All fodder crops yield data are considered for inventory by the Statistics Estonia as green fodder. Data about the biomass of the collected grass fodder is not differentiated and specified (e.g. hay, silage, green fodder, the proportion of legumes). Due to lack of data, the use of straw has been left out of the nitrogen gross balance calculation.

5.4.2 Strength and weakness

The Estonian approach has to deal with lack of data and therefor default values are used. However, manure production is not a very constant value, because it depends on many factors, among others diet composition, water consumption, environmental conditions and housing system. Moreover, because of N volatilisation, determination of the N content depends on the time after defecation. Similar large variations are found for default values for feed intake, feed composition (N content) and feed digestibility and this affects the relationship of those data with N excretion. For example, feed digestibility has to be assumed to be constant (75%) for all pig categories and ages within categories.

For all types of breeding pigs one category is used with an average weight of 75 kg. It is unclear whether or not adult breeding sows (weight range 140 – 220 kg) are included in this category. N excretion of adult breeding sows is considerable higher compared to that of gilts.

The standard nutrient contents of manure differ significantly from the determined N contents in pig manure ranged from the Danish Environmental Protection Agency (2013), indicating different nutrient contents of the ingested feeds. Data to verify this observation are not available.

For poultry, an average value of 0.6 kg N excreted per bird per year is assumed. However, N strongly varies with the type of poultry (Jongbloed and Kemme, 2005). According to these authors, annual N excretion ranged from 0.31 kg/bird in broiler breeder pullets to 0.99 kg/bird in adult broiler breeder. Distinguishing more bird categories will improve the accuracy of the estimation of the N excretion from poultry.

Currently, no information is available regarding phosphate excretion from livestock in Estonia.

6 France

6.1 Methodology

The France methodology for calculation of the nitrogen and phosphate excretion is based on a system described by the Comité d'Orientation pour der Pratiques agricoles respectueses de L'Environnement (CORPEN) (2003; 2006). For ruminants this methodology calculates the mineral excretion at animal level for a numerous number of cattle categories and scenarios either per month or per lifetime. For sows including piglets, this methodology calculates the mineral excretion on animal level for a 365 days period. For weaned piglets and growing finishing pigs, the excretion is based on an animal base. Excretions are calculated according to a balance approach, thereby subtracting mineral deposition in animal product from mineral intake via feed. For this calculation, the following data are required:

- N and P content of diets
- Feed intake levels
- Amount of produced animal products
- N and P contents of animal products.

N and P contents of diets, feed intake levels and mineral deposition values are all based on the values published by CORPEN (Report_Corpen, 2003).

6.2 Animal categories

Cattle:
Suckling cow, finishing cull cow, foetal growth, replacement dairy cattle, replacement suckling cattle, veal calf, rosé calf (beef), rosé calf (dairy), beef cattle.

Pigs:
Starter weanling pigs Standard, starter weanling pigs 2-Phase, grower weanling pigs Standard, grower weanling pigs 2-Phase, starter growing finishing pigs, growing finishing pigs (start), growing finishing pigs (finish), standard sow, lactating sow, gestating sow.

Poultry:
Male and female rearing hens (<18 weeks), laying hens (cage housing, floor housing, label, organic, free range), broiler breeder pullets (< 19 weeks), male and female broiler breeders (standard and label), broiler (export, standard, heavy birds, young cocks, label, organic).

6.3 Data origin

6.3.1 Grazing animals

6.3.1.1 Lactating dairy cattle

Principles to calculate excretions of N, P and K of lactating cattle in France have been established by the " Lactating cattle sub-group" of the "Animal Nutrition group" within CORPEN, which was reported in 1991. Calculations of excreted amounts of N (, P and K) per animal are based on the mineral balance e.g. the difference between mineral intake and mineral retention:

- Feed characteristics (N, P and K concentrations and nutritive values) were obtained from Feeding Tables INRA (Sauvant et al, 2004). This resulted in average values as presented in Table 6.1 and used to calculate mineral intake.
- Feed dry matter intake was estimated either from equations used in the "Inration" feed evaluation programme of INRA (Beaumont et al, 1999) based in energy and nutrient requirements and assuming a zero nutrient balance. Mineral intake has been calculated by multiplying dry matter intake of various feeds with mineral composition of those feeds.
- Secretion of N and P in milk were fixed at 5.1 and 0.9 g/kg milk, respectively.

Table 6.1. Nitrogen and phosphorus concentrations in different feeds used in calculations of N and P excretion by lactating and growing ruminants

Feed	N Category		P Category	
	Dairy	Beef	Dairy	Beef
Fresh grass	28.8	24.0	4.0	3.7
Ensiled grass	24.0	19.2	3.4	3.0
Grass hay	24.0	14.4	3.4	3.0
Maize silage	13.1	13.1	2.0	2.5
Energy-rich concentrates/grains	18.4	18.4	3.1	3.7
Protein-rich concentrates/soybean meal	83.2	83.2	7.8	7.8
Concentrates for calves		27.6		3.5
Milk replacer		36.0		8.0

Various feeding scenarios are reported as examples for calculating mineral excretions. Monthly excretions were calculated for animals fed and housed indoor or (partly) grazing on pasture. Basic calculations assume an annual milk yield of 6,000 kg per cow. For cows producing more than 6,000 kg of milk, excretions should be increased with 5% per 1,000 kg milk extra. Excretions of N and P used for dairy cows fed a single forage are presented in Table 6.2.

Table 6.2. Assumed monthly excretions of N and P (kg) of a dairy cow (production level: 6,000 kg of milk per year) fed a single type of forage

Forage	N	P
Maize silage	6.7	1.3
Preserved grass	9.1	1.4
Fresh grass	11.2	1.5

Data from Table 6.2 are used to calculate mineral excretions for different scenarios (Table 6.3).

6.3.1.2 Growing cattle

Principles to calculate excretions of N, P and K of growing cattle in France have been established by the "Cattle sub-group" of the "Animal Nutrition group" within CORPEN, which was reported in 2001. Calculations of excreted amounts of N (, P and K) per animal are based on the mineral balance e.g. the difference between mineral intake and mineral retention:

- Feed characteristics (N, P and K concentrations and nutritive values) were obtained from Feeding Tables (INRA) or from a "large database" containing chemical analyses of feeds. This resulted in average values for 8 feed types (fresh grass, grass hay, grass silage, maize silage, energy-rich concentrates/grains, protein-rich concentrates/soybean meal, concentrates for calves and milk replacer) that were used for the calculations (Table 6.1)
- Feed intake was estimated either from equations used in the "Inration" feed evaluation programme (INRA), or by expert opinion. It was reported that both approaches yielded similar results.
- Retention of P and K were fixed at 7 and 2 g per kg live weight gain, respectively, while N retention depended on type of production / animal (Table 6.4)

Excretion data were reported for various animal categories under various feeding and fattening strategies. Data were reported as excretion per month, per specific period (see example in Table 6.5) or per kg live weight per month. From the latter, equations were derived to estimate monthly mineral excretion from live weight (Table 6.6).

Table 6.3. N and P excretions from dairy cows on various feeding regimens

Feeding regimen		**Ration**	**Excretions/yr/cow**	
			N	**P**
P> 40% grazing	100% grazing	100% pasture gazing	134.4	18.0
	> 40% fresh grass, > 30% maize	60% pasture grazing, 30% maize silage , 10% preserved grass	114.7	17.0
		40% pasture grazing, 45% maize silage , 15% preserved grass	118.5	17.0
	> 40% fresh grass, < 30% maize	50% pasture grazing, 10% maize silage , 40% preserved grass	108.0	17.0
		50% preserved grass, 40% pasture grazing, 10% maize silage	114.5	17.0
> 50 % maize	> 50% maize and < 40% fresh grass	50% maize silage, 50% pasture grazing	106.8	16.8
		50% maize silage , 40% pasture grazing, 10% preserved grass	104.8	16.0
	> 75% maize	75% maize silage, 25% preserved grass	93.6	16.8
	100% maize	100% maize silage	80.4	15.6
> 50% preserved grass	> 75% preserved grass	75% preserved grass, 25% maize silage	102.0	15.6
		100% preserved grass	109.2	16.8
	50% preserved grass and 50% maize	50% maize silage, 50% preserved grass	94.8	16.8
	> 50% fresh or preserved grass	75% preserved grass, 25 % pasture grazing	122.4	16.6
		50% preserved grass, 50 % pasture grazing	126.0	16.8

Table 6.4. Nitrogen retention by cattle categories

Category	N retention (g/kg live weight gain)
Suckling cow	0
Finishing cull cow	16
Foetal growth	29
Replacement dairy cattle	24
Replacement suckling cattle	29
Veal calf[1]	n.p.[4]
Rosé calf[2], beef breed	n.p.
Rosé calf, dairy breed	n.p.
Beef cattle[3]	n.p.

[1]Rapidly-growing animals raised with milk replacer from birth until maximum 215 kg, slaughtered at 5 months
[2]Rapidly-growing animals raised on maize silage from minimum 270 to maximum 720 kg, slaughtered between 8 and 18 months
[3]Slowly-growing animals, raised on different forages from minimum 450 to maximum 800 kg live weight slaughtered at 24 to 36 months.
[4]n.p.: not clearly reported, likely 29 g/kg live weight gain

Table 6.5. Examples of N excretion by various categories of rapidly-growing beef cattle per period. N excretion presented as kg/animal.

Category	Age, month	LW range, min – max, kg	Feeding regimen	Live weight range		
				Light	Medium	Heavy
Veal calf	0 to 5	30 – 215	Milk replacer		6	
Rosé beef	8 to 18	300 – 720	Maize silage	39	43	46
	8 to 12	270 – 480	Grass hay	14	14	14
	8 to 12	270 - 480	Maize silage	11	13	13
	8 to 17	280 – 500	Grass & hay	39	41	44
	8 to 17	280 – 500	Grass & maize silage	41	44	49
Rosé dairy	0 to 12	30 – 430	Maize silage		29	
	12 to 18	430 – 640	Maize silage		27	

Table 6.6. Equations to estimate monthly N excretion (g/animal) for different feeding regimen and animal categories

Feeding regimen	Category		
	Lactating cow	Growing cattle	Fattening cattle
Grass	20.4 LW – 3100	11.7 LW + 100	15.3 LW - 1800
Grass hay	4.9 LW + 1400	4.6 LW + 1100	12.2 LW - 1000
Grass silage	4.0 LW + 3200	5.9 LW + 1400	12.9 LW
Maize silage	12.5 LW – 3500		9.4 LW - 300

[1]LW: live weight in kg

6.3.2 Pigs

Table 6.7 provides the N and P contents in different categories of pigs (Report_Corpen, 2003).

Table 6.7. The N and P contents (g/kg live weight) in different categories of pigs in France (Report_Corpen, 2003)

Category	Estimated weight (kg)	Age/ Physiological state	N-content (g/kg)	P-content (g/kg)
Weaned piglet	8 – 30	?	18.3	4.0
Growing -Finishing pig	30 – 112	?	18.5	3.8

The N and P contents of the different categories of pig diets are provided in Table 6.8.

Table 6.8 N and P contents (g/kg) in different categories of pig diets (Report_Corpen, 2003)

Category	N-content	P-content
Starter diet weanling pigs Standard	33.6	7.5
Starter diet weanling pigs 2-Phase	32.0	6.8
Grower diet weanling pigs Standard	30.4	6.5
Grower diet weanling pigs 2-Phase	28.8	5.8
Starter diet growing finishing pigs	28.0	5.8
Grower diet growing finishing pigs	26.4	4.8
Finisher diet growing finishing pigs	24.0	4.4
Standard sow diet	26.4	6.5
Lactating sow diet	26.4	6.0
Gestating sow diet	22.4	5.0

Table 6.9 provides the N and P balance for the different pig categories.

Table 6.9 N and P balance for the different pig categories on a year or an animal base (Report_Corpen, 2003)

Category	Feed intake (kg)	N intake (kg)	P intake (kg)	N deposition (kg)	P deposition (kg)	N excretion (kg)[3]	P excretion (kg)[1,3]
Average present sow incl. piglets (8 kg), year basis [2]	1200	27.3 – 31.5	6.3 – 7.6	6.9	1.5	20.4 – 24.6	4.8 – 6.11 (11.0 – 14.0)
Weaned piglet (8 – 30 kg), animal basis	38	1.11 – 1.17	0.23 – 0.26	0.55	0.12	0.56 – 0.62	0.11 – 0.14 (0.25 – 0.32)
Growing–finishing pig (30 – 112 kg), animal basis	235	5.86 – 6.63	1.06 – 1.35	2.07	0.43	3.79 – 4.56	0.63 – 0.92 (1.44 – 2.11)

[1]) Phosphate excretion between brackets.

[2]) Based on a performance level of 25.3 weaned piglets per productive sow and 21.2 weaned piglets per average present sow.

[3]) First value is based on a 2-phase feeding system; the second value is based on a standard feeding system.

6.3.3 Poultry

Table 6.10 provides the N and P contents in different categories of poultry (Report_Corpen 2006)

Table 6.10. The N and P contents (g/kg live weight) in different categories of poultry (Report_Corpen 2006)

Category	Weight (g)	Age/ Physiological state	N-content (g/kg)	P-content (g/kg)
Egg (broiler breeder)			17.4	2.15
Day-old broiler pullet				
Broiler Standard		Slaughter	29.6	4.6
Broiler Organic & Label		Slaughter	32.8	4.8
Broiler breeder hen			32.8	4.8
Broiler breeder male				
Egg (laying hen)			17.4	2.15
Day-old hen pullet				
Laying hen			32.8	4.8

The N and P contents of the different categories of poultry diets are provided in Table 6.11.

Table 6.11 N and P contents (g/kg) in different categories of poultry diets (Report_Corpen 2006)

Category	N-content	P-content
Laying hen diet	26.6	4.5
Broiler breeder diet	23.6	4.4
Broiler diet Export	30.7	6.1
Broiler diet Standard	30.1	5.6
Broiler diet Heavy birds	29.8	6.0
Broiler diet Young cocks	31.7	6.5
Broiler diet Label	27.0	5.3
Broiler diet organic	27.0	5.6

Table 6.12 provides the N and P balance for the different poultry categories.

Table 6.12 N and P balance for the different poultry categories on an animal base (Report_Corpen 2006)

Category	Intake (kg)			Deposition (kg)		Excretion (kg)	
	Feed	N	P	N	P	N	P[1]
Male and female rearing hens (<18 weeks)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Laying hens Cage housing	39.2	1.043	0.176	0.330	0.042	0.713	0.134 (0.307)
Laying hen Floor housing	36.8	0.979[2]	0.166[2]	0.276	0.036	0.703	0.130 (0.297)
Laying hen Label	39.8	1.059[2]	0.179[2]	0.282	0.037	0.777	0.142 (0.326)
Laying hen Organic	37.6	1.000[2]	0.169[2]	0.282	0.036	0.718	0.133 (0.304)
Laying hen Free range	38.2	1.0162[2]	0.172[2]	0.282	0.036	0.734	0.136 (0.311)
Broiler breeder pullets (< 19 weeks)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Male and female Broiler breeders Standard	50.7	1.197	0.223	0.454	0.032	0.743	0.191 (0.437)
Male and female Broiler breeders Label	54.2	[3]	[3]			1.068	0.258 (0.591)
Broiler Export	2.46	0.076	0.015	0.038	0.006	0.038	0.009 (0.021)
Broiler Standard	3.41	0.103	0.019	0.052	0.008	0.051	0.011 (0.025)
Broiler Heavy birds	3.94	0.117	0.024	0.049	0.007	0.068	0.017 (0.038)
Broiler Young cocks	1.37	0.043	0.009	0.021	0.003	0.022	0.006 (0.013)
Broiler Label	6.78	0.183	0.036	0.063	0.009	0.120	0.027 (0.061)
Broiler Organic	7.63	0.206	0.043	0.081	0.013	0.125	0.030 (0.069)

[1]) Phosphate excretion between brackets.
[2]) Assuming that the N and P content was similar to that of the feed supplemented to cage housed hens.
[3]) No contents of Label diets available; using the contents of standard broiler breeder diet resulted in a negative value for the P deposition.

6.4 Assessment

6.4.1 Complexity of methodology

Dairy Cattle
Mineral excretions have been estimated for 10 to 15 feeding scenarios, which reflects the (regional) differences between dairy farming systems. Excretions were standardized for a cow producing 6,000 kg of milk per year. Excretions are corrected for lower or higher production (5% per 1,000 kg of milk).
No information is available on the number or proportion of dairy cattle within each feeding scenario.

Beef Cattle
Meat and beef production in France is highly diverse with a variety of cattle breeds and feeding regimens. In the CORPEN report, tables of N, P and K excretion are presented for an abundant number of situations, reflecting this high diversity in production systems and methods. Excretion data are mainly reported per month or cycle, and annual excretion data are restricted to suckling cows (Figure 6.1) and replacement cattle (dairy and suckling). Thus data for other growing cattle cannot be directly compared with those of other countries.

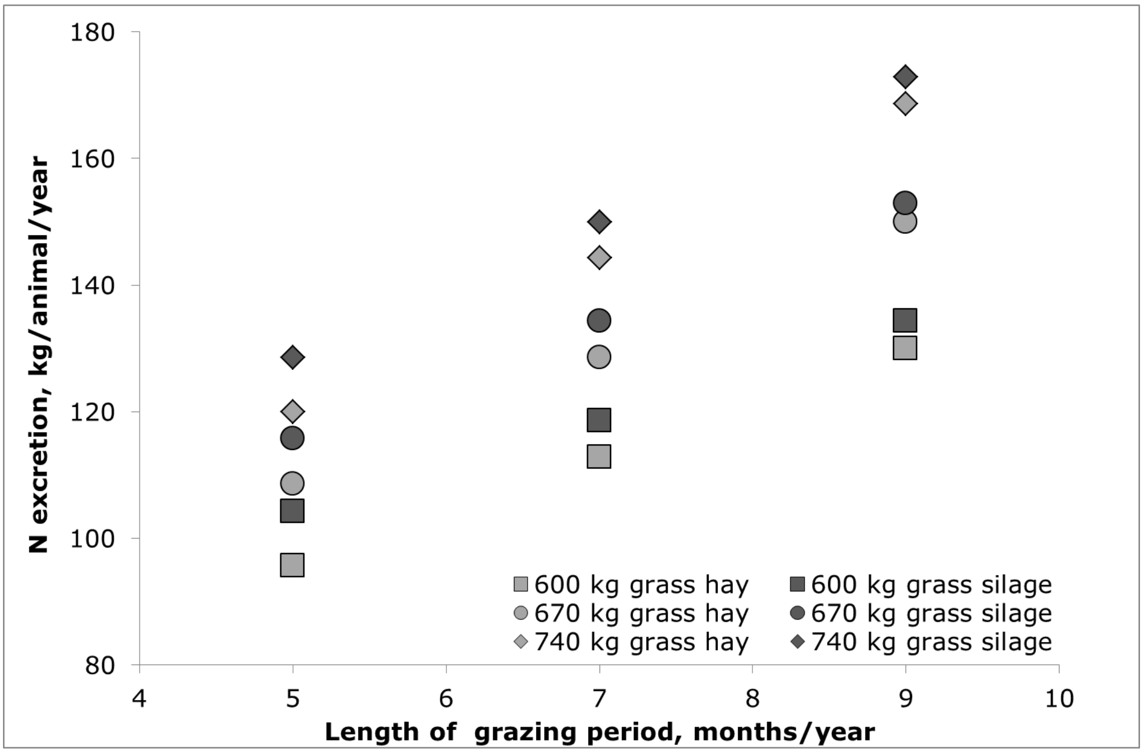


Figure 6.1. Effect of animal size (live weight: 600, 670 or 740 kg), length of grazing period and type of winter feeding (grass hay or grass silage) on the annual N excretion by suckling cows.

Although it is stated in the report that feed characteristics are based on a large database and on the tabulated values (INRA), only average values extracted from these data were reported. It is not clear whether these average data were used to calculate mineral intake of all different categories. If average values were used, it can be debated why regional differences in feed characteristics have not been considered. However, it should be realised that this would further complicate the estimation of N excretion by growing cattle.

Pigs
In France, only one category for pig reproduction is used. In this category rearing sows, gestating sows, lactating sows, and boars are averaged, which might include a lot of errors in estimating the mineral excretion.

Poultry
In France, a lot of different marketing systems for layers and broilers are taken into account, and these systems are distinguished in calculation of mineral excretion.

6.4.2 Strength and weakness

The French system has to deal with a large variety of animals and regions. By using the modelling approach instead of input/output measurements transparency of method is ensured. Important is that data origin is of good quality, although in official documents only average data are represented.

7 Germany

7.1 Methodology

The German methodology for calculation of the nitrogen and phosphate excretion is based on a system described by DLG (2005) and Haenel et al. (2012). This methodology calculates the mineral excretion on animal level for a 365 days period. The excretion is calculated according to a balance approach, thereby subtracting mineral deposition in animal product from mineral intake via feed. For this calculation, the following data are required:

- N and P content of diets
- Feed intake levels
- Amount of produced animal products
- N and P contents of animal products.

The analysis of the system used in Germany is based on the DLG brochure "Bilanzierung der Nährstoffausscheidungen landwirtschaftlicher Nutztiere" (DLG, 2005). This brochure has been prepared by the DLG-working party of Feed and Animal Nutrition Referees and describes the methodology, assumptions and calculations used to estimate the excretion of nitrogen and phosphate by livestock animals and the resulting outcome. Since the publication of this brochure, additional update brochures have been published to adjust the methodology (DLG, 2008) or to add other animal categories to the listing (DLG, 2008; 2009).

7.2 Animal categories

Standard mineral excretion on animal level is calculated for a number of animal categories and production systems.

7.3 Data origin

Mineral content of diets is extracted from Feed , published by DLG.
Feed intake levels are estimated based on energy requirements and diet composition typical for various production systems. Variations in type of feed and feeding strategies have been recognised, especially in the estimation of mineral consumption of herbivores. Circumstances and feeding strategies have been formulated based on "Good Agricultural Practice".
Mineral deposition in the animal is calculated as: mineral content in the animal at final weight (g/kg) x corresponding weight of the animal (kg) minus mineral content in the animal at starting weight (g/kg) x corresponding weight (kg). Mineral retention per unit of growth depends on the age of the animal and on growth rate (intensity of the production system). Thus, standard values of mineral intake, retention, and excretion have been formulated for a large variety in circumstances.

7.3.1 Grazing animals

7.3.1.1 Cattle

For cattle, standard mineral excretions have been calculated for different categories (calves, young stock, dairy cattle, beef cattle and suckling cows) within different production systems (Table 7.1). However, for dairy cattle also an alternative method for estimating nitrogen excretion has been introduced in 2008 (DLG, 2008). In this method, nitrogen excretion is calculated as a function of total milk and total milk nitrogen secretion and the concentration of milk urea nitrogen:

N-excretion (g/d) =
124 + 1320 x milk urea (g N/kg milk) + 1.87 x milk N yield (g/d) – 6.90 total milk yield (kg/d)

Farmers may deviate from using the standard values by calculating the farm-specific mineral excretion. In that case, farm-specific data and records of feed use, performance and analysed mineral contents in feeds are required.

The excretions presented in Table 7.1 have been calculated by using assumed nitrogen and phosphorus contents per unit of growth or secreted product, and by assuming a required amount of metabolisable energy for the type and level of production. To meet the metabolisable energy requirements for the considered production, typical diet compositions have been formulated. No references were published as a basis for diet formulation. Therefore, it is anticipated that type and proportions of feeds used by the different animal categories and under different production systems, were discussed within the DLG-working party of Feed and Animal Nutrition Referees. Nitrogen and phosphorus contents in feeds are based on Feed tables, published and updated by DLG.

For instance, calves are assumed to consume during their first 16 weeks of life:

40 kg of milk
40 kg of milk replacer
135 kg of a concentrate mixture and
100 kg of hay dry matter.

This approach resulted in mineral balances for the different cattle categories as is presented in Table 7.1.

Table 7.1. Cattle categories and estimated standard N and P excretions (kg/animal/year)

Category	Description	System	Excretion ex animal	
			N	**P**
Calf	Young animal gaining 80 kg in live weight during 16 weeks		5.1	0.9
Replacement heifer	Young animal first calf at 27 mo of age and gaining 580 kg in live weight	Grassland products, conventional	60.0	8.1
		Grassland products, extensive	54.4	7.7
		Crop based with pasture	49.5	7.2
		Crop based, confined	42.8	6.7
Dairy cow, Holstein	Lactating animal, producing milk containing 4.0% of fat and 3.4% of protein and producing 0.9 calf/yr	Grassland based, 6,000 kg milk/yr	118.8	16.8
		Grassland based, 8,000 kg milk/yr	132.0	18.4
		Grassland based, 10,000 kg milk/yr	149.0	20.0
		Crop based with pasture, 6,000 kg milk/yr	103.8	15.6
		Crop based with pasture, 8,000 kg milk/yr	118.4	17.6
		Crop based with pasture, 10,000 kg milk/yr	138.0	20.0
		Crop based no pasture, 6,000 kg milk/yr	100.8	15.6
		Crop based no pasture, 8,000 kg milk/yr	115.2	17.6
		Crop based no pasture, 10,000 kg milk/yr	135.0	20.0
Dairy cow, Jersey	Lactating animal, producing milk containing 6.0% of fat and 4.0% of protein and producing 0.9 calf/yr	Crop based with pasture, 4,000 kg milk/yr	95.2	15.1
		Crop based with pasture, 6,000 kg milk/yr	102.5	16.1
		Crop based with pasture, 8,000 kg milk/yr	117.5	18.3
Beef steers	Fattening Holstein male cattle weighing 45 kg at the start and 625 kg at slaughter (18 mo)		35.3	6.7
	Fattening male cattle weighing 45 kg at the start and 700 kg at slaughter (18 mo)		40.1	6.8
Suckler cow	Lactating animal weighing 500 kg and producing 0.9 calf/yr weighing 180 kg at weaning		86.8	12.1
	Lactating animal weighing 700 kg and producing 0.9 calf/yr weighing 220 kg at weaning at 6 mo		105.6	14.3
	Lactating animal weighing 700 kg and producing 0.9 calf/yr weighing 310 kg at weaning at 9 mo *(2008)*		116.4	15.5
Rosé cattle	Beef cattle (male and female) weighing 50 kg at start and 350 kg at slaughter and fattened on low iron diets		19.3	3.0
Starter calf beef	Calf reared from 80 to 220 kg live weight		3.0	0.4
	Calf reared from 80 to 210 kg live weight on diets low in nitrogen and phosphorus *(2008)*		2.1	0.3
Veal calf	Male and female cattle fed with milk replacer feed weighing 50 kg at start and 250 kg at slaughter		2.8	0.6

Table 7.2. N and P balances for the different categories of cattle.

Category	Description System	Nitrogen			Phosphorus		
		Intake	**Retention**	**Excretion**	**Intake**	**Retention**	**Excretion**
Calf	LW gain 80 kg in 16 weeks	7.1	2	5.1	1.3	0.5	0.9
Replacement heifer	Grassland products, conventional	66.4	6.4	60.0	9.6	1.6	8.1
LW gain 580 kg in	Grassland products, extensive	60.8	6.4	54.4	9.2	1.6	7.7
27 months	Crop based, with pasture	56.0	6.4	49.5	8.8	1.6	7.2
	Crop based, confined	49.2	6.4	42.8	8.2	1.6	6.7
Dairy cow, Holstein	Grassland based, 6,000 kg milk/yr	152.2	32.7	119.5	23.1	6.2	16.9
	Grassland products, 8,000 kg milk/yr	175.1	43.4	131.7	26.3	8.2	18.1
	Grassland based, 10,000 kg milk/yr	203.4	54.0	149.4	30.6	10.2	20.4
	Crop based + pasture, 6,000 kg milk/yr	136.7	32.8	103.9	21.7	6.2	15.5
	Crop based + pasture, 8,000 kg milk/yr	161.3	43.4	117.9	25.6	8.2	17.4
	Crop based +pasture, 10,000 kg milk/yr	192.1	54.0	138.1	30.2	10.2	20.0
	Crop based no pasture, 6,000 kg milk/yr	133.6	32.8	100.8	21.6	6.2	15.4
	Crop based no pasture, 8,000 kg milk/yr	158.3	43.4	114.9	25.4	8.2	17.2
	Crop based no pasture, 10,000 kg milk/yr	189.0	54.0	135.0	30.1	10.2	19.9
Dairy cow, Jersey	Crop based with pasture, 4,000 kg milk/yr	120.7	25.5	95.2	19.3	4.2	15.1
	Crop based with pasture, 6,000 kg milk/yr	140.4	37.9	102.5	22.3	6.2	16.1
	Crop based with pasture, 8,000 kg milk/yr	167.8	50.3	117.5	26.4	8.2	18.3
Beef steers	Fattening from 45 kg to 625 kg within 18 mo	45.0	9.7	35.3	9.0	2.3	6.7
	Fattening from 45 kg to 700 kg within 18 mo	51.1	10.9	40.1	9.3	2.6	6.8
Suckler cow	500 kg LW producing 180 kg calf, extensive system	90.9	4.1	86.8	13.1	1.0	12.1
	700 kg LW producing 220 kg calf, intensive system	110.6	5.0	105.6	14.5	1.2	13.3
	700 kg LW producing 310 kg calf, intensive system	123.3	7	116.4	17.1	1.7	15.5
Rosé cattle	Concentrate based diet, 300 kg LW gain	25.1	5.8	19.3	4.4	1.4	3.0
Starter calf beef	Cattle reared from 80 to 220 kg live weight	4.4	1.4	3.0	0.8	0.3	0.4
	Cattle reared to 210 kg LW at low N&P regimen	3.3	1.2	2.1	0.6	0.3	0.3
Veal calf	Male and female cattle on milk replacer feed	5.3	2.4	2.8	1.2	0.6	0.6

7.3.2 Pigs

Table 7.3 provides the N and P contents in different categories of pigs (DLG, 2005)

Table 7.3 The N and P contents (g/kg live weight) in different categories of pigs (DLG, 2005)

Category	Estimated weight (kg)	Age/Physiological state	N-content (g/kg)	P-content (g/kg)
Pig	All categories	All categories	25.6	5.1

The N and P contents of the different categories of pig diets are provided in Table 7.4.

Table 7.4 N and P contents (g/kg) in different categories of pig diets (DLG, 2005)

Category	N-content	P-content
Diet weanling pigs (1-phase)	29.6	6.0
Grower diet weanling pigs (< 15 kg)	29.6	6.0
Starter diet weanling pigs (≥ 15 kg)	28.0	5.5
Starter diet growing finishing pigs (< 40 kg). Standard; daily gain 700 g/d	28.8	5.5
Starter diet growing finishing pigs (< 40 kg). Standard; daily gain 800 g/d	29.6	5.5
Grower diet growing finishing pigs (≥40 kg). Standard; daily gain 700 g/d	27.2	5.5
Grower diet growing finishing pigs (≥40 kg). Standard; daily gain 800 g/d	28.0	5.5
Starter diet growing finishing pigs (< 40 kg). N and P low; daily gain 700 g/d	28.0	5.5
Starter diet growing finishing pigs (< 40 kg). N and P low; daily gain 800 g/d	28.8	5.5
Grower diet growing finishing pigs (≥40 kg). N and P low; daily gain 700 g/d	26.4	5.0
Grower diet growing finishing pigs (≥40 kg). N and P low; daily gain 800 g/d	27.2	5.0
Finisher diet growing finishing pigs (≥60/70 kg). N and P low; daily gain 700 g/d	22.4	4.5
Finisher diet growing finishing pigs (≥60/70 kg). N and P low; daily gain 800 g/d	23.2	4.5
Rearing sow diet (1-phase)	28.0	6.0
Rearing sow diet (2-phase, I)	28.0	6.0
Rearing sow diet (2-phase, II)	23.2	5.0
Boar diet	28.8	5.5
Standard sow diet	27.2	6.0
Lactating sow diet	28.0	5.5
Gestating sow diet	23.2	4.5

Table 7.5 provides the N and P balance for the different pig categories.

Table 7.5 N and P balance for the different pig categories on a year base (DLG, 2005)

Category	Feed intake (kg)	Nitrogen, kg				Phosphorus, kg		
		Intake	Deposition	Excretion		Intake	Deposition	Excretion[1]
Sow incl. piglets (28 kg BW) standard; Performance level of 20 piglets	1850	52.0	15.4	36.6		11.1	3.1	8.0 (18.32)
Sow incl. piglets (28 kg BW) N/P low; Performance level of 20 piglets	1880	49.7	15.4	34.3		9.8	3.1	6.7 (15.34)
Sow incl. piglets (28 kg BW) standard; Performance level of 22 piglets	1920	54.1	16.8	37.3		11.5	3.4	8.1 (18.55)
Sow incl. piglets (28 kg BW) N/P low; Performance level of 22 piglets	1950	51.7	16.8	34.9		10.2	3.4	6.8 (15.57)
Breeding sow (28 kg – 115 kg); Standard	266[2]	15.4	4.6	10.8		3.32	0.92	2.40 (5.50)
Breeding sow (28 kg – 115 kg); N/P low	266[2]	13.6	4.6	9.0		2.92	0.92	2.00 (4.58)
Breeding sow (115 kg – 1st mating); standard	150[2]	21.6	6.15	15.5		4.95	1.22	3.73 (8.54)
Breeding sow (115 kg – 1st mating); N/P low	150[2]	19.5	6.15	13.3		4.50	1.22	3.28 (7.51)
Boar (breeding)	820	23.6	1.5	22.1		4.50	0.3	4.20 (9.62)
Piglets (8 – 28 kg); standard	35[2]	6.75	3.33	3.42		1.37	0.66	0.71 (1.63)
Piglets (8 – 28 kg); N/P low	35[2]	6.62	3.33	3.29		1.29	0.66	0.63 (1.44)
Growing–finishing pig (28 – 117 kg); DG level 700 g/d; Standard	268[2]	17.3	5.4	11.9		3.47	1.07	2.40 (5.50)
Growing–finishing pig (28 – 117 kg); DG level 700 g/d; N/P low	268[2]	15.2	5.4	9.80		3.00	1.07	1.93 (4.42)
Growing–finishing pig (28 – 117 kg); DG level 800 g/d; Standard	259[2]	19.7	6.15	13.56		3.84	1.22	2.62 (6.00)
Growing–finishing pig (28 – 117 kg); DG level 800 g/d; N/P low	262[2]	17.4	6.15	11.23		3.32	1.22	2.10 (4.81)

[1]) Phosphate excretion between brackets [2]) Feed intake per animal; other data on an annual base.

7.3.3 Poultry

Table 7.6 provides the N and P contents in different categories of poultry (DLG, 2005)

Table 7.6 The N and P contents (g/kg live weight) in different categories of poultry (DLG, 2005)

Category	Weight (g)	Age/ Physiological state	N-content (g/kg)	P-content (g/kg)
Egg broiler breeder	62	-	19.3	1.9
Day-old broiler pullet	42	1 day	30.4	3.4
Broiler	2100	Slaughter	27.8	4.4
Broiler breeder hen	2000	≥19 weeks	33.4	4.9
Broiler breeder male	2750	≥19 weeks	34.5	5.4
Egg laying hen	62.5	-	18.5	1.7
Day-old hen pullet	35	1 day	30.4	3.4
Laying hen	1900	≥18 weeks	28.0	5.6

The N and P contents of the different categories of poultry diets are provided in Table 7.7.

Table 7.7 N and P contents (g/kg) in different categories of poultry diets (DLG, 2005)

Category	N-content	P-content
Laying hen diet phase 1, standard	28.0	6.0
Laying hen diet phase 2, standard	28.0	6.0
Laying hen diet phase 1, N/P low	27.2	4.5
Laying hen diet phase 2, N/P low	27.2	4.5
Rearing hen diet phase 1 (wk 1 – 3)	33.6	7.0
Rearing hen diet phase 2 (wk 4 – 7)	27.2	6.0
Rearing hen diet phase 3 (wk 8 – 12)	22.4	5.0
Rearing hen diet phase 4 (wk 13 – 16)	20.8	4.5
Rearing hen diet phase 5 (wk 17 – 19)	26.4	4.5
Broiler diet phase 1; standard	36.8	7.5
Broiler diet phase 2; standard	35.2	6.5
Broiler diet phase 3; standard	33.6	6.0
Broiler diet phase 1; N/P low	35.2	7.0
Broiler diet phase 2; N/P low	32.8	5.5
Broiler diet phase 3; N/P low	31.2	5.0

Table 7.8 provides the N and P balance for the different poultry categories.

Table 7.8 N and P balance for the different poultry categories on a year base (DLG, 2005)

Category	Feed intake (kg)	N intake (kg)	P intake (kg)	N deposition (kg)	P deposition (kg)	N excretion (kg)	P excretion (kg)[1]
Rearing hens, (<18 weeks) 3.3 kg weight gain, standard	15.5	0.402	0.109	0.116	0.021	0.286	0.088 (0.202)
Rearing hens, (<18 weeks) 3.3 kg weight gain, N/P low	15.5	0.360	0.078	0.116	0.021	0.244	0.057 (0.131)
Laying hens (≥ 18 weeks), 17.6 kg Egg mass, standard	40.0	1.120	0.240	0.334	0.032	0.786	0.208 (0.476)
Laying hens (≥ 18 weeks), 17.6 kg Egg mass, N/P low	40.0	1.088	0.180	0.334	0.032	0.754	0.148 (0.339)
Broilers, 1.7 kg weight gain, Standard[2]	2.85[2]	0.802	0.148	0.483	0.069	0.319	0.079 (0.181)
Broilers, 1.7 kg weight gain, N/P low[2]	2.85[2]	0.749	0.126	0.483	0.069	0.266	0.057 (0.131)
Broilers, 2.0 kg weight gain, Standard[2]	3.6[2]	0.889	0.164	0.497	0.071	0.392	0.093 (0.213)
Broilers, 2.0 kg weight gain, N/P low[2]	3.6[2]	0.830	0.140	0.497	0.071	0.333	0.069 (0.158)
Broilers, 2.2 kg weight gain, Standard[2]	4.2[2]	0.984	0.181	0.515	0.074	0.469	0.107 (0.245)
Broilers, 2.2 kg weight gain, N/P low[2]	4.2[2]	0.918	0.154	0.515	0.074	0.403	0.080 (0.183)

[1]) Phosphate excretion between brackets.
[2]) Feed intake per animal; other data on an annual base.

7.4 Assessment

7.4.1 Complexity of methodology

Diet composition is based on an expert judgement and consequently no references for this judgement can be extracted from literature. The standard values for mineral excretion have been established in 2005. Since then, additional brochures have been published (all concerning cattle):

- January 2008: Producing starter calves for beef at a reduced nitrogen and phosphorus regimen
- January 2008: Suckler cows weaning calves at 6 and 9 months
- January 2008: Dairy cow productions systems without pasturing (hay fed
- January 2008: Estimating nitrogen excretion by dairy cows using milk urea content and milk performance
- June 2009: Milk production in crop based systems with Jersey cattle

These updates can be retrieved on the internet, but there seems to be no regular update or specific website for this information. It is therefore uncertain whether other additional brochures have been published.
Mineral excretions are expressed in different units:

- Per animal place per year for young animals that reach their final live weight within 1 year: calf, rosé cattle, young beef and veal calf
- Per animal for animals that reach their final live weight in more than 1 year: replacement heifer and beef cattle. The data presented in the DLG brochure have been corrected to obtain annual excretion data
- Per animal (place) per year for dairy cattle and suckler cows.

The extrapolation of the excretion of individual animals to the excretion of the total national population per animal category is based on inventories of animal numbers of the Statistisches Bundesamt every second year, farm structure surveys of cattle and pig populations twice a year on a national basis and the official agricultural census, latest in 2010. In addition, for cattle the database with registration of individual animals per district has been used from 2010 onwards. Some additional adjustments are made to distinguish the required pig categories. This approach allows an accurate estimate of animal numbers (Haenel et al., 2012). The original and additional brochures describe the standard mineral excretion of 15 different pig, 10 different poultry and 24 different cattle categories/production systems. Also standard diets versus diets low in N and P are taken into account for some animal categories. Standard excretions are available for the majority of livestock production systems within Germany.

For cattle mineral intake has been calculated as a function of energy requirements that is balanced by the consumption of energy from a certain diet. The composition of the diet is standardised for various production systems. The formulation of standard diets specific for a certain production system is carried out by the experts within the DLG-working party of Feed and Animal Nutrition Referees.
Literature used for calculating N balances is DLG publications concerning energy and protein requirements and Feed Evaluation Tables for various livestock animals. These publications have been published between 1987 and 2004.

For pigs and poultry a number of different standard situations have been defined to calculate the excretion per animal. In general 2-3 production levels (number of piglets per sow, growth rate in pigs, age and weight at slaughter in broilers) are defined in combination with standard and low N/P-diets. Feed use is calculated on the basis of energy requirements for the respective production levels and combined with standard and low N/P-diets based on DLG-recommendations (DLG, 2005). Standard farm conditions are incidentally updated using information of experts in the field.

7.4.2 Strength and weakness

The German system uses the modelling approach and is therefore not susceptible to variation or inaccuracy in input/output measurements. By choosing this less accurate methodology data origin becomes more important for the quality of the excretion coefficients. The strength of the German system is that data origin is well documented and of good quality.

8 Ireland

8.1 Methodology

The Irish standards for excretion of livestock share the same basis as the UK standards. They also consider the current standards across the EU Member States. The computation of these data is based largely on the well-known approach of nutrient balance, although alternative methods for quantifying nutrient excretion have been considered. The balance method requires comparing total animal intakes with outputs in terms of animal products, including milk, eggs, wool and live weight gain. The variability between standards reflects the variability in dietary composition, feed conversion efficiency and livestock husbandry and also differences in age and animal live weight and length of production cycle.

8.2 Animal categories

Several categories of animals are distinguished:

Grazing animals

Cattle :
Dairy cow, Suckler cow , Cattle (0-1 year old), Cattle (1-2 years old), Cattle > 2 years

Small ruminants:
Mountain ewe & lambs, Lowland ewe & lambs , Mountain hogget, Lowland hogget , Goat

Other grazing animals:
Horse (>3 years old), Horse (2-3 years old), Horse (1-2 years old), Horse foal (< 1 year old), Donkey/small pony, Deer (red) 6 months 2 years, Deer (red) > 2 years,
Deer (fallow) 6 months -2 years, Deer (fallow) > 2 years, Deer (sika) 6 months — 2 years, Deer (sika) > 2 years

Monogastrics

Pigs:
Breeding unit (per sow place), Integrated unit (per sow place), Finishing unit (per pig place)

Poultry:
Laying hen per bird place, Broiler per bird place, Turkey per bird place

8.3 Data origin

The data used in Ireland are identical to the UK data except for dairy cows which is due to different circumstances and farm systems. Therefore, the information in paragraphs 8.3.1.2 and on is identical to the UK chapter. The Irish standards have been collated from several sources, including scientific and review papers (Netherlands, UK, Sweden, Germany, Flanders), documents produced by national research centres (Swiss and Denmark), or from government institutions (France, Germany), many following approaches to scientific contacts. They span from 1997 to 2003, with some of them subject to yearly review, (e.g. Netherlands and, more recently, Denmark). All the data were determined by, or took account of, nutrient balances, knowing the feed intake and the amount used for metabolism, growing and production. The main differences between them are due to the different categories used in each country, which can vary greatly according to performance (i.e. level of milk production) age and size within the same species. As far as possible, data have been collated according to similar categories, and where this has not been possible then the category names used have been retained. The N standards (Table 8.1) are taken from the Nitrates regulations in Ireland reported in the European Communities regulations (good agricultural practice for protection of waters), Statutory Instruments (SI) No. 610, 2010. The excretion standards take account of nitrogen losses thought to occur during storage and assumed to be 10 % for ruminants and 25-30% for pigs and poultry, in line with ERM recommendations (ERM, 1999).

Table 8.1 Annual nutrient excretion rates (kg/animal/year) for livestock

Livestock type	Total N[1]	Total P
Dairy cow	85	13
Suckler cow	65	10
Cattle (0-1 year old)	24	3
Cattle (1-2 years old)	57	8
Cattle > 2 years	65	10
Mountain ewe & lambs	7	1
Lowland ewe & lambs	13	2
Mountain hogget	4	0.6
Lowland hogget	6	1
Goat	9	1
Horse (>3 years old)	50	9
Horse (2-3 years old)	44	8
Horse (1-2 years old)	36	6
Horse foal (< 1 year old)	25	3
Donkey/small pony	30	5
Deer (red) 6 months 2 years	13	2
Deer (red) > 2 years	25	4
Deer (fallow) 6 months2 years	7	1
Deer (fallow) > 2 years	13	2
Deer (sika) 6 months — 2 years	6	1
Deer (sika) > 2 years	10	2
Breeding unit (per sow place)	35	8
Integrated unit (per sow place)	87	17
Finishing unit (per pig place)	9.2	1.7
Laying hen (per bird place)	0.56	0.12
Broiler (per bird place)	0.24	0.09
Turkey (per bird place)	1.0	0.4

[1] N losses assumed to be 10 % overall

8.3.1 Grazing animals

8.3.1.1 Dairy cows

A stochastic budgetary simulation model of a dairy farm[2] has been developed to allow investigation of the effects of varying biological, technical, and physical processes on farm profitability (Shalloo et al., 2004). This model, which estimates grass and silage intakes, uses a mass balance approach to calculate N output per cow per annum. For a milk yield of 4676 kg/cow/annum, the model estimates N intake of 121.1 kg and N utilisation - in milk, live weight gain and calf - of 27.1 kg, giving an estimated N excretion of 94 kg. The ERM (1999) model would predict N excretion of 98 kg/cow/annum.

Grass either grazed or as grass silage can make up more than 85% of the diet of ruminant livestock in Ireland (Table 8.2). The N concentration in the grass is 26.4 g/kg when averaged across grazed grass and grass silage. The N concentration in the grazed grass is 28.8 g/kg, which is close to the lower threshold required for optimum photosynthesis (Parsons and Chapman, 2000). The N concentration in the grass silage is lower (21.6 g/kg) because the grass that is harvested for silage is at a more advanced stage of maturity.

[2] The Moorepark Dairy Systems Model, Teagasc, Moorepark, Fermoy, Co. Cork, Ireland

Table 8.2. The annual diet of the 'average' Irish Dairy Cow (kg/cow)

	Intake (DM)	N content (g/kg DM)	Intake (N)	P content (g/kg DM)	Intake (P)
Grazed grass	2546	28.8	73.32	3.5	8.91
Grass silage	1272	21.6	27.48	3.5	4.45
Concentrate	669	30.4	20.34	5.2	3.48
Total Input			121.14		16.84
Calf sales			1.33		0.27
Cow weight gain			0.90		0.26
Milk sales			24.92		4.21
Total Output			27.15		4.74
Gaseous loss			9.40		__
Organic load			84.59		12.10

The typical system of dairy production in Ireland is based on seasonal production where cows calve during a twelve week period in spring (February, March and April), produce milk during the grass growing season (February to November) and are dried off during November or early December as the supply of grazed grass runs out. Lactation lengths range between 250 and 290 days per year. Compact calving in spring is an integral part of this system. This system maximises output of milk from grazed grass, which is a low cost and natural source of feed for dairy cows.
Grazed grass composes most of the diet during lactation. The relatively low energy density of this diet limits the amount of milk a cow can produce each year. Hence, in Ireland the type of cow used on dairy farms and the level of milk output per cow is substantially different from that more typical of continental Europe where large cows produce large volumes of milk fuelled by high energy diets largely composed of maize silage and imported concentrates and where grazed grass plays a minor or no role in the diet. This accounts for the difference in organic N excretion by dairy cows in Ireland compared to cows in many other European countries.

8.3.1.2 Calves (identical to UK)

Typical values for feed and N intakes for an 8-week weaned calf are shown in Table 8.3. The annual N output per 'calf place' assumes a 7-day empty period between calves, but this figure will have relevance on specialist calf rearing units only, where calf pens are occupied for much of the year. In other circumstances, where heifer calves are kept as replacements for milking cows, the N excretion per individual calf is the relevant figure to be considered in the manure nutrient inventory for the farm.

Table 8.3. Calculation of manure N excretion based on typical feed and N intakes for a dairy calf weaned at 8 weeks.

Parameter	Units	Values
Birth weight	Kg	40
Weaning weight	Kg	65
Feeding period	Days	56
N content of gain	g/kg	27.5
N retained	kg/calf	0.7
Mean milk powder consumed	kg/day	0.5
Mean dry coarse feed consumed	kg/day	0.6
N content of milk powder	g/kg	35.2
N content of coarse mix	g/kg	27.0
N intake	kg/calf	2.3
N excretion	kg/calf	1.6
N excretion	kg/calf place/year	9.3

8.3.1.3 Suckler cows (identical to UK)

Suckler cows differ from dairy cows in that the calf typically remains with the mother for up to six or seven months before being weaned. It is possible to calculate, by mass balance, the N excretion by different sizes of suckler cow.

Table 8.4. Production data and manure N outputs for suckler cows with calf.

	Small breed	Large breed
Adult cow weight, kg	450	600
DMI (kg DM/year)	2956	3942
N intake, kg/year	76	100
LW gain of cow, kg	30	30
N in gain cow, kg/year*	0.8	0.8
Calf weaning weight, kg	180	250
N in calf, kg/year*	7.3	7.3
N in animal products	8.0	8.0
N excretion, kg/year	68	92

* ERM (1999) reference values

8.3.1.4 Growing cattle (identical to UK)

Available data illustrate the differences that can occur in N excretion between production systems, particularly as a result of differences in diet N content.

Table 8.5. Estimated manure N excretion by growing cattle on different production systems.

Parameter	Units	Grass silage-based diets	Cereal beef production
Initial weight	Kg	49	90
Final weight	Kg	552	440
Feeding period	Days	456	270
Feed consumed	kg DM	3484	1667
Feed N	g/kg DM	24	22.4
Feed N consumed	kg/animal	83.6	37.3
Liveweight gain	Kg	503	348
N content of live weight gain	g/kg	27	27
N in live weight gain	Kg	13.6	9.4
N excretion	kg/animal	70	28
N excretion	kg/animal place/year	56	38

The ERM (1999) report, on which the European Communities (2002) was based, recognised the importance of breed type, age (or size) and dietary N content, on N excretion.

Table 8.6. Nitrogen Production Standards (kg N/animal/year) proposed for growing cattle of small and large breeds with different age intervals; averages for male and female animals (ERM, 1999).

Growing cattle	Small breed			Large breed		
	Age (years)			Age (years)		
	0-1	1-2	2-3	0-1	1-2	2-3
% N in diet						
Low (2.0%)*	18	31	35	24	41	47
Medium (2.7%)	24	43	48	32	57	64
High (3.4%)	30	55	61	40	74	81

* 2.3% for animals of 0-1 year old.

8.3.1.5 Grower/fatteners older than 24 months (identical to UK)

The majority of cattle reared for meat reach maturity within 18 months of age. Relatively few beef cattle reared for meat are kept beyond 24 months of age. For those that are, rates of live weight gain and protein deposition are generally low, while protein (N) intakes are usually well in excess of requirements. Nitrogen excretion per animal per day is therefore relatively high. Furthermore, these cattle are unlikely to be retained for a year, and therefore any estimate of N excretion on a farm will need to take account of the length of time that they are on the farm. Many factors will influence the amount of N excreted by these animals but, as an approximate estimate, a value of 152 g/animal/day is proposed (i.e. 56 kg N/animal place/year).

8.3.1.6 Bull beef (identical to UK)

A common practice is to feed a high protein concentrate at a fixed rate (kg/head/day) during the entire life of the animal, with forage fed to appetite; as animals grow and forage intake increases, so the protein content of the diet declines, matching the reduced need for protein as the animal matures. Based on typical feed and production data, N excretion has been estimated for Holstein bulls on cereal and silage (grass and maize)-based diets (Table 8.7).

Table 8.7. Feed and production data, with estimated N balance for (Holstein) bulls.

Parameter	Units	Cereal beef	Maize silage	Grass silage beef
Weaning weight	kg	90	90	90
Age at slaughter	months	13	15	16
Slaughter weight	kg	480	490	500
LWG, weaning to slaughter	kg/day	1.35	1.1	1
Feed consumed				
Concentrate	kg/animal	1872	510	1040
Maize silage	kg DM/animal	-	1920	1500
Nitrogen intake	kg	35.9	65.3	61.5
N in gain	g	5118	5610	5746
Total N excretion	kg/animal	30.8	59.7	55.8
Total N excretion*	kg/animal place/yr	38.9	59.9	49.7

** Note. Annual excretion based on 289, 364 and 410 days growth periods, respectively, for these production systems*

8.3.1.7 Dairy heifer replacements (identical to UK)

The N content of the diet of replacement heifers will vary according to age and season. Many heifers will predominantly be at pasture during the summer months, where the N content of grass can vary from 22 to 35 g N/kg DM. In winter months, dairy heifer replacements are usually fed conserved forages plus concentrate feeds, in which dietary N contents tend to be nearer 26 g/kg DM. Average values of 27 and 26 g N/kg DM for diets in the first and second years, respectively, have been used in the calculations in Table 8.8.

Table 8.8. Estimated N excretion by replacement dairy heifers.

Parameter	units	2-12 months	12-24 months
Initial weight	kg	49	310
Final weight	kg	310	580
Feeding period	days	304	365
Feed consumed	kg DM/day (mean)	4.2	7.5
Feed N	g/kg DM	27	26
Feed N consumed	kg/animal	34.5	73.9
Liveweight gain	kg	261	270
Empty bodyweight gain	kg	156.6	162
N content of live weight gain	g/kg	28	28
N in live weight gain	kg	4.4	3.9
N excretion*	kg/animal	30.1	67.2

** Note. Estimate for young heifer on animal place/yr may include N excretion for the 0-2 month period of the calf, i.e. 1.6 kg/calf (Table 8.3).*

8.3.1.8 Proposed N output standards cattle other than dairy cows (identical to UK)

Table 8.9. Manure N output standards for cattle, with allowances for gaseous N losses from housing and manure storage

Stock	Class	LW	Excreta Daily	Occup.	Previous Standards	Annual N output & source			N production standards after calculated N losses	
						Proposed	Other	ERM		
		kg	kg or l	% year	$kg.yr^{-1}$	$kg.yr^{-1}$	$kg.yr^{-1}$	$kg.yr^{-1}$	ex-house	ex-store
Dairy heifer replacemet	2-12 mths	50-310	*20*	100	-	32.0			29.3 (8%)	29.1 (9%)
Dairy heifer replacement	13-24 mths	310-580	*40*	100	-	67.0			61.3 (8%)	60.9 (9%)
Beef suckler	Large	600	*45*	100	58	92.0	54	94	83.6 (9%)	83.0 (10%)
Beef suckler	Small	450	32	100	-	68.0		63	61.9 (9%)	61.2 (10%)
Grower	>2 years		32	100	58	56.0	54	64	50.9 (9%)	50.5 (10%)
Grower	18 mths	520	26	100	47	56.0		57	50.9 (9%)	50.5 (10%)
Grower place	12 mths	270	*20*	100	-	38.0	46		34.6 (9%)	34.3 (10%)
Grower	3 - 12 mths			83	-	31.6			28.8 (9%)	28.4 (10%)
Bull beef	3– 15mths	490	*26*	100	-	60.0			54.6 (9%)	54.1 (10%)
Br. Bulls	<2 years	550	*26*	100	-	56.0			50.9 (9%)	50.5 (10%)
Br. Bulls	Adult	650	*26*	100	-	53.0			48.2 (9%)	47.8 (10%)
Calf place	2 months	65	7	89	7	9.3	-	-	8.9 (5%)	7.9 (15%)
Calf	Per animal			15		1.6	-	-	1.5 (5%)	1.4 (15%)

Note: Above estimates based on slurry management system.

8.3.1.9 Ewes plus lambs (identical to UK)

As with other livestock, the factor that has the greatest effect on N excretion per ewe is the N content of the diet, with increasing N intake resulting in an increase in N excretion.

Table 8.10. Production data and N outputs for 75 kg live weight lowland ewes with offspring

Parameter	Units	Production data	N balance (kg/ewe/year)
Live lamb production	no./ewe/year	1.2	
Slaughter weight lambs	kg	38	
Total N intake	kg/ewe/year		13.4
Annual weight change ewe	kg	+4	
Wool production	kg/ewe/year	3	
N content of lambs	g/kg	13.0	0.59
N content of ewe live weight gain	g/kg	9	0.04
N content of wool	g/kg	165	0.50
Total N retention	kg/ewe/year		1.13
N excretion	kg/ewe/year		12.3

8.3.1.10 Store lambs (identical to UK)

Weaned lambs that have not been finished by the beginning of October are generally termed 'store lambs'. Depending on the type of lamb and feedstuff available, the stores are finished on short- or long-term keep. Estimates of N excretion for store lambs are given in Table 8.11.

Table 8.11. Production data and N outputs for store lambs

Parameter	Units	Short keep	Long keep
Liveweight at start	kg	35	35
Liveweight at slaughter	kg	50	60
N content of gain	g/kg	27.2	27.2
N retention	kg	0.41	0.68
Feeding period	days	56	150
DM intake	kg/d	0.7	0.5
N content of diet	g/kg	23	17
N intake	kg/lamb	0.90	1.28
N excretion	kg/lamb	0.49	0.60

8.3.1.11 Goats (identical to UK)

As for dairy cows, rations for dairy goats consist of forages and concentrates, although during non-lactating periods only forages are fed. In the absence of any other data, values for the N content of feed and live weight gain proposed by Ketelaars and van der Meer (2000) have been used.

Table 8.12. Estimates of annual N intake and excretion by milking goats.

Parameter (units)	
Live kid production (per female)	1.8
Adult female weight (kg)	65
Weaning weight of kids (kg)	7.0
Nitrogen intake	
Feed intake (% of live weight)	3.50
Feed intake (kg/female)	830
N content of feed (g/kg)	29.0
N intake (kg/female)	24.1
Nitrogen retention	
Live weight gain female (kg)	2
Live weight production kids (kg/female)	13
N content live weight females (g/kg)	24
N content kids (g/kg)	35
Milk production (kg/female)	600
N content milk (g/kg)	5.0
N retention in female gain (kg)	0.05
N retention kids (kg/female)	0.44
N retention milk (kg/female)	3.0
Total N retention (kg/female)	3.5
N excretion (kg/female)	**20.6**

8.3.1.12 Horses (identical to UK)

The amount of feed consumed by the healthy animal is influenced by many factors, but is principally determined by the energy needs of the horse, to support maintenance, activity, pregnancy, lactation etc. Intake may then be modified by the quality of the feed available and the ability of the gastrointestinal tract to hold that amount of feed. Most horses are fed dry matter intakes near to 2.5% of live weight (Hanson et al., 1996). The results of a survey of typical horse feeding practices in the UK, undertaken in the 1990's, are given in Table 8.13.

Table 8.13. A guide to the amounts of forage and concentrates fed to horses (in dry matter as % of live weight) in the UK according to a number of nutritionists

Type of Animal	% of Body weight on an as fed basis ***Figures in bold italic refer to ratios of feed***		
	Forage	Concentrates	Total
Mature horse at maintenance	2 1.5-1.8 1.5-2 ***95***	0 0.2- 0.5 0 - 0.5 ***5***	2 2 1.75 - 2
Mares late gestation	1.2 1.4-1.8 1.5-2.0 ***non-TB* 80*** ***TB 40***	0.8 0.2-0.6 0.25-0.75 ***non-TB 20*** ***TB 60***	2 2 2-2.25
Mares early lactation	1.5 1.5 1.5 –1.75 ***non-TB 80*** ***TB 40***	1 1.5 1-1.5 ***non-TB 20*** ***TB 60***	2.5 3 2.5-3
Mares late lactation	1.4 1.5-1.75 1.25 –1.75 ***non-TB 90*** ***TB 50***	0.6 0.75-1.0 0.75-1.25 ***non-TB 10*** ***TB 50***	2 2-2.5 2-2.5
Light work	1.4 1.5-1.8 1.5-2.0 ***90***	0.6 0.2-0.6 0.1-0.75 ***10***	2 2 1.75- 2.25
Moderate work	1.5 1 1-1.5 ***80***	1 1 0.5-1.0 ***20***	2.5 2 2-2.5
Intense work	1.25 1-1.25 0.75-1.5 ***50***	1.25 1.25-1.5 1.25-1.5 ***50***	2.5 2.5 2-2.75
Dressage	- 1-1.5	- 0.5-1	2.5 2
Racing – flat	0.6 1-1.25 ***40***	1.4 - 1.9 1.25 –1.5 ***60***	2-2.5 2-2.5
Racing National Hunt	0.6 1.25 ***50***	1.4 - 1.9 1.25 ***50***	2.5 2-2.5
Show jumping	1.5 –1.75 1.2 ***80***	0.75 – 1 0.8 ***20***	2.5 2
Eventing	1.5 1.25-1.5 ***70***	1 1-1.25 ***30***	2.5 2-2.5
Hunting	1.5 –1.75 1-1.2 ***50***	0.75-1.0 0.8-1 ***50***	2.5 2
Weanling foal 6 months : TB	0.75 ***40***	1.75 ***60***	2.5

* Thoroughbred

Table 8.13 continued….	% of Body weight on an as fed basis Forage	 Concentrates	 Total
Weanling foal 6 months : Non-TB	1 ***50***	1.5 ***50***	2-2.5
Yearling foal 12 months : TB	1.2 1-1.2 ***50***	0.8 0.8-1.0 ***50***	2 2
Yearling foal 12 months : non –TB	1.2 1-1.2 1.25-1.5 ***70***	0.8 0.8-1.0 0.5-1.0 ***30***	2 2 2-2.25
Long Yearling: TB	1.2 1.25 –1.5 ***50***	0.8 1-1.25 ***50***	2 2-2.5
Long Yearling: Non- TB	1.2 1.4 ***70***	0.8 0.6 ***30***	2 2
Two year old : TB	1.4 1.4 1.0-2.0 ***40 Racing***	0.6 0.6 0.5-1.0 ***60***	2 2 2-2.5
Two year old : non TB	1.4 1.5 1.25-1.75 ***80***	0.6 0.5 0.5-0.75 ***20***	2 2 2-2.25

8.3.1.13 Deer (identical to UK)

Deer are ruminants and their diets consist predominantly of forage therefore, although for farmed deer some concentrate feeds may be given They exhibit seasonal changes in patterns of digestion. There is little evidence of differences between deer and sheep in most aspects of nitrogen (N) digestion and metabolism and, consequently, at the same N intakes the two species have not been found to differ in apparent N digestibility or the amount of N excreted in the urine. The nutritional requirements of adult hinds are presented in Table 8.14.

Table 8.14. Dry matter and N intakes of adult hinds (95 kg live weight)

	Days	Dry Matter Intake (kg/day)	Crude Protein (% DM)	N intake (kg)
Non-pregnant	60	1.7	10	1.6
Early to mid pregnancy	150	2.0	10	4.8
Late pregnancy	80	2.3	14	4.1
Lactation	75	3.0	17	6.1
Total	365			16.7

Source: Adam (1994)

8.3.1.14 Young deer (identical to UK)

Typical feed and N intakes of deer calves from weaning at 3-4 months of age up to 15-16 month of age are summarised in Table 8.15.

Table 8.15. Feed and N intake by weaned red deer calves (based on Adam, 1994)

	Days	Live weight gain (g/day)	DMI (kg/day)	Crude protein (%)	N intake (kg)
3-6 months (Sept-Dec)	90	140-200	1.0-1.5	16-17	3.0
6-8 months (Dec-Feb)	60	0-40	1.0-1.3	10	1.0
8-11 months (Feb-May)	90	90-270	1.3-2.2	12-17	4.3
11-16 months (May-Oct)	150	100-200	1.5-2.5	14	6.7
Total	390				15.0

8.3.1.15 Proposed N output standards other (than cattle) categories grazing animals (identical to UK)

Table 8.16. Manure N output standards for sheep, goats, deer and horses, with allowances for gaseous N losses before landspreading

Stock	Class	LW kg	Excreta Daily kg or l	Occup. % year	Previous Standards $kg.yr^{-1}$	Annual N output & source: Proposed $kg.yr^{-1}$	Annual N output & source: Other $kg.yr^{-1}$	Annual N output & source: ERM $kg.yr^{-1}$	N production standards after calculated N losses: ex-house	N production standards after calculated N losses: ex-store
Sheep										
Adult ewes (FYM)						-			-	-
Hill ewe + lamb	lamb 30-35kg	40-55kg	*3.3 (3.8)*	100	-	7.6			7.6 (-)	7.6 (-)
Lowland ewe+ lamb[3]	lamb 35-40kg	60-80kg	*5.0 (5.8)*	100	9	12.3		12.9	12.1 (2%)	11.9 (3%)
Lambs – FYM	Short stores	35 – 50	*1.8 (2.1)*	16		0.49		-	-	0.49 (-)
Lambs – FYM	Long stores	35 – 60	*1.8 (2.1)*	41	1.2	0.60		-	-	0.60 (-)
Goat										
Milking goats	Housed	65	*3.5 (4.0)*	100	-	20.6	9.0	16.5	17.9 (13%)	15.0 (27%)
Deer										
Breeding hinds		95	*5.0 (5.8)*	100		16.2			15.7 (3%)	15.2 (6%)
Calves - finishers		45-100kg	*3.5 (4.0)*	100		13.4			12.7 (5%)	12.0 (10%)
Horse										
Adult horse	2-3 years	400	24.5	100	-	23.1	44.0	39.0	22.2 (4%)	21.0 (9%)
	> 3years	600					50.0	53.0		

Notes:-

8.3.2 Pigs

8.3.2.1 Sows and piglets (identical to UK)

In a typical commercial pig unit, sows and piglets remain with their mothers for 3-4 weeks until they are approximately 7 kg live weight, when they are weaned. Estimates of feed intake and composition are required separately for dry and lactating sows. It is assumed that the piglets consume only sows' milk. The minerals (N/P) in output consists of the minerals in the piglets and the minerals in the live weight of the sows. To estimate the minerals retained in sows, a typical annual replacement rate (40%) has been used. UK industry standards for sows are used in Table 8.17, to estimate annual mineral excretion.

Table 8.17. Production data and N outputs for sows and piglets

Parameter	
Weaning weight piglets (kg)	7
Piglets weaned (per sow per year)	23
Feed intake sow (kg)	
Dry sow	710
Lactating sow + weaning ration	439
N content of sow feed (g/kg)	
Dry sow	20.0
Lactating sow + weaning ration	27.2
N intake sow (kg/sow/year)	**26.1**
Nitrogen retention	
Live weight production of piglets (kg)	161
N content of live weight gain - sow (g/kg)	25.6
N content of live weight gain - piglet (g/kg)	30.4
N retention sow (kg/year)	1.10
N retention piglets (kg/year)	4.89
Total N retention (kg/year)	5.99
Nitrogen excretion (kg/sow)	**20.1**

8.3.2.2 Growing finishing and fattening pigs (identical to UK)

This category refers to pigs reared for slaughter, from weaning to slaughter. From weaning to slaughter takes approximately 140 days which, together with a 7 day period between batches for cleaning of the accommodation and restocking might allow 2.48 production cycles per year. (however, see footnote to Table 8.15, which details typical production data). Table 8.18 provides the N and P contents in different categories of pigs (Cottrill and Smith, 2010; Cottrill et al., 2010)

Table 8.18 The N and P contents (g/kg live weight) in different categories of pigs (Cottrill and Smith, 2010; Cottrill et al., 2010)

Category	Estimated weight (kg)	Age/ Physiological state	N-content of live weight (g/kg)	P-content (g/kg)
Weaned piglet 1	7.0	3 – 4 weeks	30.4	5.0
Weaned piglet 2	12.0		25.0	5.0
Growing pig	30.0		25.0	5.0
Finishing pig	65.0		25.0	5.0
Rearing sow	90 – 130	19 – 29 weeks	22.0	?
Breeding sow		Dry + lactating	25.6	?
Sow at slaughter	250	1 wk after weaning	25.6	?
Boar	250		27.4	?

The N and P contents of the different categories of pig diets in the UK are provided in Table 8.19.

Table 8.19 N and P contents (g/kg) in different categories of pig diets (Cottrill and Smith, 2010; Cottrill et al., 2010)

Category	N-content	P-content without phytase	P-content with phytase
Starter diet weanling pigs (7-12 kg)	35.2	6.8	5.8
Grower diet weanling pigs (12-30 kg)	32.0	6.5	5.5
Starter diet growing finishing pigs (30-65 kg)	29.6	6.0	5.0
Finisher diet growing finishing pigs (65-100 kg)	27.2	5.7	4.6
Rearing sow diet (90 – 130 kg)	25.6	6.5	5.5
Lactating sow diet + weaning ration	27.2	6.8	5.8
Gestating sow diet	20.0	6.5	5.5
Boar Diet	24.8	?	?

Table 8.20 provides the N and P balance for the different pig categories in the UK.

Table 8.20 N and P balance for the different pig categories on a year base (Cottrill and Smith, 2010; Cottrill et al., 2010).

Category	Feed intake (kg)	N intake Cumulative live weight (kg)	P intake -/- phytase (kg)	P intake +/+ phytase (kg)	N deposition (kg)	P deposition (kg)	N excretion (kg)	P excretion -/- phytase (kg)[1]	P excretion +/+ phytase (kg)[1]
Sow incl. piglets (7 wk of age)	1149	26.10	8.21	6.91	5.99	1.08	20.1	7.13 (16.33)	5.83 (13.35)
Breeding sow (90 – 130 kg)	770	19.73	5.01	4.11	4.23	1.51	15.5	3.50 (8.02)	2.60 (5.95)
Piglets phase 1 (7 – 12 kg)	92	3.21	0.62	0.53	1.91	0.38	1.30	0.24 (0.55)	0.15 (0.34)
Piglets phase 2 (12 – 30 kg)	292	9.31	1.96	1.66	4.11	0.87	5.20	1.09 (2.50)	0.79 (1.81)
Grower phase (30 – 65 kg)	570	16.90	3.42	2.86	5.90	1.18	11.00	2.24 (5.13)	1.68 (3.85)
Finisher phase (65 – 100 kg)	778	21.23	4.54	3.75	6.22	1.29	15.01	3.25 (7.44)	2.46 (5.63)
Growing–finishing pig (25 – 100 kg)	576	16.68	3.45	2.87	5.76	1.16	10.9	2.29 (5.24)	1.71 (3.92)
Boar (250 kg)	1095	27.16	?	?	2.00	?	25.16	5.2 (11.91)	4.4 (10.08)

[1]) Phosphate excretion between brackets.

8.3.2.3 Proposed N output standards for pigs (identical to UK)

Table 8.21. Manure N output standards for pigs, with allowances for gaseous N losses before landspreading

Stock	Class		Excreta		Previous standards	Nitrogen output & source				N production standards after calculated N losses	
	Age	LW	Daily	Occup.		Proposed		Other	ERM		
	Range/Ave.	kg	kg or l	% year	N $kg.yr^{-1}$	$kg.pig^{-1}$	$kg.yr^{-1}$	N$kg.yr^{-1}$	N $kg.yr^{-1}$	ex-house	ex-store
1 sow place, inc litters[5]		220	10.9	100	19.5	22.8	22.8	35.0	21.5	19.7 (13%)	18.0 (21%)
1 sow place, inc litters[5]		220	10.9	100	-	20.1	20.1			17.5 (13%)	16.0 (21%)
Maiden gilt – FYM		90-130	5.6 (6.4)	90	13.0	3.22	15.5			12.8 (18%)	11.1 (29%)
Boar – FYM		250	8.7 (10.0)	100			25.0			20.6 (18%)	17.5 (30%)
Weaner 1	23-40 days	7-12	1.3 (2.2)	71	3.0	0.09	1.3			1.2 (10%)	1.0 (18%)
Weaner 2	40-73 days	12-30	2.0 (3.6)	82	6.1	0.57	5.2			4.7 (10%)	4.2 (18%)
Grower	73-120 days	30-65	3.7 (7.1)	88	9.4	1.64	11.0			8.4 (23%)	7.7 (30%)
Finisher	120-164 days	65-100	5.1 (10.0)[13]	86		2.12	15.0			11.5 (23%)	10.6 (30%)
Weaner – Finisher	23-164 days	7-100	3.5	95	10.5		10.9	9.2	10.1	8.4 (23%)	7.7 (30%)

Notes:-

8.3.3 Poultry (identical to UK)

For rearing pullets, a total of 2.9 cycles per year is possible, based on a 16 week cycle and 2 weeks downtime for removal, cleaning and restocking.
Laying hens arrive at the layer farm at 17 wk of age and continue laying until end of lay, typically at 72 weeks of age. A two phase feeding program is followed. During the first 28 weeks, a slightly higher (17% CP) protein diet is fed, compared to a 16% CP diet during in weeks 46 – 72.
For broilers, a total of 7.4 cycles per year is realized, based on a 42 d cycle and 1 week downtime for removal, cleaning and restocking.

Table 8.22 provides the N and P contents in different categories of poultry (Cottrill and Smith, 2010; Cottrill et al., 2010).

Table 8.22 N and P contents (g/kg live weight) in different categories of poultry (Cottrill and Smith, 2010; Cottrill et al., 2010)

Category	Weight (g)	Age/ Physiological state	N-content (g/kg)	P-content (g/kg)
Egg broiler breeder	65	-	18.8	1.8
Broiler breeder pullet	42 - 2300	< 25 weeks	30.0	4.6
Broiler	0 – 2150	Slaughter	30.0	4.6
Broiler breeder hen	2300 - 3500	≥25 weeks	29.1 – 30.4	4.6
Egg laying hen	63.5 – 65.5	-	18.5	1.8
Rearing hens	35 – 1350	0 – 16 weeks	35.0	5.5
Laying hen	1350 - 2005	≥17 weeks	28.0	5.5

The N and P contents of the different categories of poultry diets are provided in Table 8.23.

Table 8.23 N and P contents (g/kg diet) in different categories of poultry (Cottrill and Smith, 2010; Cottrill et al., 2010)

Category	N-content diet	P-content -/- phytase	P-content +/+ phytase
Laying hen diet phase 1	27.2	6.0	5.0
Laying hen diet phase 2	25.6	5.5	4.5
Rearing hen diet phase 1 (0 – 3 weeks)	33.6	7.5	6.5
Rearing hen diet phase 2 (4 – 8 weeks)	30.4	7.5	6.5
Rearing hen diet phase 3 (9 – 16 weeks)	24.8	7.5	6.5
Broiler breeder pullet diet (0 – 6 weeks)	30.4	4.5	4.5
Broiler breeder pullet diet (7 – 18 weeks)	24.0	4.5	4.5
Broiler breeder pullet diet (19 – 24 weeks)	25.6	4.5	4.5
Broiler breeder diet	24.0	4.4	4.4
Broiler diet phase 1 (0 – 10 d)	36.0	7.6	6.4
Broiler diet phase 2 (11 – 23 d)	34.4	7.1	6.1
Broiler diet phase 3 (24 – 32 d)	30.4	6.8	5.8
Broiler diet phase 4 (33 – 42 d)	30.4	6.8	5.8

Table 8.24 provides the N and P balance for the different poultry categories.

Table 8.24 N and P balance for the different poultry categories on a year base (Cottrill and Smith, 2010; Cottrill et al., 2010)}

Category	Feed intake (kg)	N intake (kg)	P intake -/- phytase (kg)	P intake +/+ phytase (kg)	N deposition (kg)	P deposition (kg)	N excretion (kg)	P excretion -/- phytase (kg)[1]	P excretion +/+ phytase (kg)[1]
Male and female rearing hens (<18 weeks)	16.2	0.432	0.122	0.106	0.136	0.037	0.296	0.085 (0.195)	0.069 (0.158)
Laying hens (cages) (≥ 18 weeks)	40.1	1.060	0.234	0.193	0.340	0.035	0.720	0.199 (0.456)	0.158 (0.362)
Laying hens (free range) (≥ 18 weeks)	42.6	1.159	0.248	0.205	0.330	0.033	0.830	0.215 (0.492)	0.172 (0.394)
Broiler breeder pullets (< 25 weeks)[2]	22.0	0.566	0.158	0.137	0.142	0.022	0.424	0.136 (0.311)	0.115 (0.263)
Male and female Broiler breeders (≥ 25 weeks)	55.4	1.331	0.317	0.260	0.308	0.032	1.022	0.285 (0.652)	0.228 (0.522)
Broilers	28.5	0.906	0.198	0.170	0.477	0.073	0.429	0.125 (0.286)	0.097 (0.222)

[1]) Phosphate excretion between brackets.
[2]) Assuming 2 cycles per year.

8.3.3.1 Proposed N output standards for poultry (identical to UK)

Table 8.25. Manure N output standards for poultry, with allowances for gaseous N losses before land spreading

Stock[1]	Age	LW	Excreta Daily	Occup.	Previous Standards	Annual N output & source			N production standards after calculated N losses	
	Range/Ave	kg	kg or l	% year	$kg.yr^{-1}$	Proposed $kg.yr^{-1}$	Other $kg.yr^{-1}$	AB-DLO $kg.yr^{-1}$	ex-house	ex-store
Laying hens – cages	392 days	1.95	0.115	97	0.66	0.72	0.56	0.79	0.45 (38%)	0.40 (45%)
Laying hens – free range	392 days	2.05	0.115	97	-	0.83			0.58 (30%)	0.53 (36%)
Broiler places	40 days	2.15	0.06	85	0.495	0.43	0.24	0.51	0.37 (13%)	0.33 (23%)
Broiler pullets	24 weeks	2.4	*0.04*	92	-	0.42	-	-	0.32 (23%)	0.29 (31%)
Broiler breeders	36 weeks	2.4 –3.5	*0.115*	95	-	1.02	-	-	0.78 (23%)	0.7 (31%)
Replacement layer pullets	16 weeks	1.35	*0.04*	89	0.125	0.30	-	-	0.23 (23%)	0.21 (31%)
Turkeys (male)	20 weeks	12.6	0.16	91	1.39	1.80	1.0	1.93	1.36 (24%)	1.23 (32%)
Turkeys (female)	16 weeks	6.1	*0.12*	88	0.65	1.34	-	-	1.02 (24%)	0.91 (32%)
Ducks	49 days	3.3	*0.1*	83	0.9	1.33	-	1.21	1.02 (23%)	0.75 (44%)
Ostriches	14 months	110	*1.6*	100	-	1.4	-	-	1.4 ( )	1.4 ( )

Notes:-

8.4 Assessment

8.4.1 Complexity of the methodology

Standards for manure N output by farm livestock, based on the nutrient balance approach have been assembled for all the major livestock categories. However, due the large number of animal categories this system becomes complex. Even more when updating leads to different animal categories or to significantly different standards.

For suckler cows the annual figures of 92 and 68 kg N/ cow per year have been obtained by N balance, for large and small animals, respectively; however, these reduce to 83 and 61 kg N/cow per year, after allowing for gaseous N losses from typical production systems. The latter values compare more closely with the previous standard of 58 kg/cow per year. One significant reason for an increase in the figure proposed for the suckler cow is that the calf is now included with the cow.

For turkeys (and other poultry), manures are often exported from the production unit directly from the buildings and so, the N coefficient "ex-house" (i.e., after discounting unavoidable gaseous N losses) seems an appropriate basis for an N production standard - giving 1.36 and 1.02 kg N/bird place/year for male and female turkeys, respectively. This compares with the previous standards of 1.39 and 0.65 kg N/bird place/year for male and female birds.

In all stock types the production cycle and "downtime" for cleaning purposes and re-stocking, has a significant impact on annual N output.

8.4.2 Strength and weakness

The strength of the method used in the Ireland (and the United Kingdom) is data origin. The review process has included extensive industry consultation, involving producer organisations, specialist consultants, research scientists, industry experts and some farmers. The derived output figures have been compared with the relevant research data available. Recent research data for pigs and poultry have provided useful validation of the proposed outputs and have given confidence both in the values and in the approaches used. Differences with similar standards or recommendations made elsewhere in Europe are generally minor and can usually be understood on the basis of the different feeding practices or management, assumptions made with respect to the composition of 'products', or in the way the figures have been derived.

The relative weakness of the system used is inherent to the method. It is emphasised that there are many influencing factors and the potential variability of any proposed 'standards' means that these figures should be used for general guidance only.

9 Italy

9.1 Methodology

Nitrogen excretion data of livestock operations which are being used in Italy have been published on 7 April 2006 in a decree by the Italian Ministry of Agriculture and Forestry Policies (Regione Emilia Romagna, 2007). This decree has been used to derive the information on nitrogen excretion data as used in Italy.

9.2 Animal categories

The animal categories used in Italy are presented in Table 9.1

9.3 Data origin

Net nitrogen excretion has been quantified for various animal categories and the amounts of N applicable to farm land has been separated into N present in solid manure and N present in liquid manure. Net N excretion is total N excretion corrected for losses by volatilization. Although net N excretion per animal has been presented as one fixed value, the division over solid or liquid manure may be different, depending on the housing system and management. For calculating the separation into net N excreted in solid manure and net N excreted in liquid manure, the volume of solid and liquid manure for various housing systems has been estimated at a large number of livestock operations. The methods used for estimating these quantities have not been further described and specified in the decree. The nitrogen excretions that have been published in the decree of 6 April 2006 have been derived from nitrogen balance measurements on farm level at a number of farms in different regions. As a result, nitrogen balances of livestock animals may vary between regions. However, in the decree average values for nitrogen excretion per animal category are presented.
To calculate N balances on farm level, feed intake on these farms has been recorded and nitrogen content of the feeds has been analysed in a certain period. The number of farms and the division in regions vary amongst animal categories.
To date, no other information or reports have been obtained on the design and individual results of these farm balance measurements. Methods for measuring N volatilization have not been reported. Thus, the origin of the data is not very transparent.

Table 9.1 Animal categories in Italy

Species	**Category**	**Description**	**N excretion kg/hd/yr**
Swine	Sow with piglets	Sow with piglets. For piglets the period between weaning and reaching 30 kg live weight is included	36.6
	Finishing pig	Pigs at a live weight from 30 kg until slaughter (relatively high: 163.4 kg)	13.6
Cattle	Lactating cow	Dairy cow, weighing 600 kg and producing on average 8,366 kg of milk per year	116
	Suckler cow	Dairy cow, weighing 593 kg and producing on average 1,000 kg of milk per year, which is directly consumed by her calf	40.5
	Replacement heifer	Young female animal reared to replace less-productive dairy cows, weighing 540 kg at first partus at an age of 28.5 months	48.3
	Fattening cattle	Non-lactating cattle fattened during 270 days until approximately 600 kg until slaughter	33.6
	White veal calf	Young animal reared on milk (replacer) for 174 days until slaughter at 253 kg live weight	11.9
Sheep and goat		Small ruminant	No data
Poultry	Laying hen	Chicken producing eggs with an average live weight of 2 kg	0.66
	Rearing hen	Young chicken reared to replace less productive laying hen at and age of 188 day at a live weight of 1.40 kg (average live weight: 0.7 kg)	0.33
	Broiler	Young chickens raised for meat production to obtain a live weight of 1.7 (females) to 3.0 (males) kg at slaughter (average live weight: 1 kg)	0.36
	Turkey, male	Male turkey, slaughtered at a live weight of 18 kg (average LW: 9 kg)	2.13
	Turkey, female	Female turkey, slaughtered at a alive weight of 8 kg (average LW: 4.5 kg)	1.03

9.3.1 Grazing animals

9.3.1.1 Dairy cows

Nitrogen balance for lactating dairy cows were estimated from data collected in 2003 at 104 farms in the Veneto region, comprising the records of 9,800 cows. Data of this study were superimposed on results obtained in the regions Emilia Romagna and Lombardi. Most of the farms (92%) used totally mixed rations ("unifeed"). Therefore, it can be presumed that cows on these farms are kept indoors permanently. Milk production varied between 4,000 and 12,000 kg/cow/yr, but surprisingly, no significant relationship was observed between production level and nitrogen excretion (r2 = 0.10). Nitrogen excretion was highly correlated (r2 = 0.44) with nitrogen intake. Consequently, nitrogen excretion levels are not differentiated for milk production level. The data are presented in Table 9.2. No standard deviations are presented, which seems reasonable taken into account the large range in milk production levels. Mean nitrogen excretion levels is 116 kg/hd/yr. However, nitrogen excretion varied from 99.6 (mean for 1st quartile) to 132.4 kg/hd/yr (4th quartile). The net nitrogen applied to land is estimated by assuming 28% nitrogen volatilisation.

Table 9.2. Nitrogen excretion of lactating dairy cows

Item		**Unity**	**1st quartile**	**mean**	**4th quartile**
N applied to land		kg/hd/yr		83	
		kg/t LW/yr		138	
N balance					
Intake		kg /head/yr	143.2	152.1	181.0
Retention		kg/head/yr	43.6	46.1	48.6
Excretion		kg/head/yr	99.6	116.0	132.4
Volatilisation		kg/kg		0.28	
Net excretion		kg/head/yr	71.7	83.5	95.3
Basic data					
Feed intake	lactation	kg DM/hd/d	17.9	19.9	21.9
	lactation + dry period	kg DM/hd/d	16.4	18.1	19.8
Feed crude protein	lactation	kg/kg	0.147	0.157	0.166
	lactation + dry period	kg/kg	0.145	0.153	0.162
Milk yield		kg/hd/yr	7,263	8,366	9,469
Milk protein content		kg/kg	0.0331	0.0339	0.0347

9.3.1.2 Suckler cows

Data for suckler cows are derived from the project on cattle husbandry carried out by the National Association of Piemontese Cattle Breeders (ANABORAPI) comprising 2,830 cows (mean live weight 593) on 58 farms. Feed intake data were obtained from experimental studies, measuring individual feed intake of 50 cows (mean live weight 555 kg) for 150 days. Feeds for nitrogen analyses were collected by ANABORAPI from 1999 to 2001. In total 2,524 hay samples and 1,229 maize silage samples were analysed. Default values for milk protein content and nitrogen retention were assumed based on ERM/AB-DLO 1999. Data are presented in Table 9.3.

Table 9.3. Nitrogen excretion of suckler cows

Item	Unity	Mean	Minimum	Maximum
N applied to land	kg/hd/yr	44		
	kg/t LW/yr	73		
N balance				
Intake	kg /head/yr	61.5	46	79
Retention[†]	kg/head/yr	7.4	5.5	9.5
Excretion	kg/head/yr	54.1	40.5	69.5
Volatilisation[‡]	kg/kg		0.25	
Net excretion	kg/head/yr	40.6	30.4	52.1
Basic data				
Feed intake lactation+ dry period	kg DM/hd/d	9.6	8.7	14.6
Feed crude protein lactation+ dry period	kg/kg	0.110	0.077	0.115
Milk yield	kg/hd/yr	1500	1000	2000
Milk protein content	kg/kg	0.0338[§]		

[†]Retention default at 12% (ERM/AB-DLO 1999)
[‡]Assumed value
[§]Default value from ERM/AB-DLO 1999

9.3.1.3 Replacement heifers

Data were obtained from 89 farms in the Veneto region and comprised 8,466 records. Values were obtained by checking feed intake, feed composition and animal transfers in 2002 and 2003. From these results a net nitrogen excretion was estimated of 34.8 kg/hd/yr (Table 9.4). Similar studies (not reported) in Emilia Romagna and Lombardi resulted in a net nitrogen excretion of 35.7 and 37.5 kg/hd/yr, respectively. Based on these values a national value of 36.0 kg of net nitrogen applied to land is being used.
The variance in nitrogen excretion is relatively high. The coefficient of variation for nitrogen excretion (48.3 kg/hd/yr) is 0.26.

Table 9.4. Nitrogen excretion of replacement heifers based on data derived from farms in Veneto region

Item	**Unity**	**Value**	**Standard deviation**	**Coefficient of variation**
N applied to land (national value)[§]	kg/hd/yr	36		
	kg/t LW/yr	120		
N balance				
Intake until weaning	kg/head/period	5.3	2.7	0.509
Intake between weaning and first partus	kg/head/period	123.9	29.7	0.240
Retention	kg/head/period	14.41		0.000
Excretion	kg/head/period	114.8	29.6	0.258
Excretion	kg/head/yr	48.3	12.5	0.259
Volatilisation	kg/kg		0.28	
Net excretion	kg/head/yr	34.8		
Basic data				
Age at weaning	days	85	23	0.271
Age at first partus	months	28.5		0.000
Live weight at birth	kg	39		
Live weight at weaning	kg	101	19	0.188
Live weight at first partus	kg	540		
Intake between weaning and first partus	kg DM/period	6473	1459	0.225
Crude protein feed	kg/kg	0.121	0.018	0.149

[$]Corrected with data from Emilia Romagna and Lombardi region

9.3.1.4 Fattening cattle

Data of fattening cattle are derived from zootechnical data collected at various sites within the interregional project “Nitrogen balances in animal husbandry”, with several assumptions. Assumptions used:

- Average live weight per animal place: 400 kg
- Nitrogen excretion: 12 kg per year per 100 kg LW
- Nitrogen excretion per animal place: 400 x 12/100 = 48 kg
- Nitrogen volatilisation: 0.30
- Average cycles per year: 1.35

Data are presented in Table 9.5.

Table 9.5. Nitrogen excretion of fattening cattle

Item	Unity	Site		
		Padova	**Torino**	**Rome**
Studies	n	491	4	24
Animals	n	36,768	140	240
N balance				
Intake	kg/head/cycle	44.2	39.1	64.1
Retention	kg/head/cycle	7.6	6.8	16.9
Excretion	kg/head/cycle	36.6	32.3	47.2
Excretion	kg/head/yr	57.2	43.3	41.3
Average live weight	kg	490	370	362
Excretion	kg/100 kg LW	11.8	11.7	11.4
Volatilisation	kg/kg		0.30	
Net excretion	kg/head/yr	40.0	30.3	28.9
Basic data				
Age at weaning	days	85	23	0.271
Age at first partus	months	28.5		0.000
Live weight at start period	kg	350	250	140
Live weight at slaughter	kg	630	500	585
Live weight gain	kg/hd/d	1.30	1.00	1.11
Cycles	d/d	1.6	1.4	0.94
Feed conversion rate	kg DM/kg LW gain	6.70	5.95	
Crude protein feed	kg/kg	0.146	0.158	

[$]Corrected with data from Emilia Romagna and Lombardi region

9.3.1.5 White veal calves

Data for white veal calves were obtained within the project "Nitrogen balances in animal husbandry" from 34 farms, comprising 49,206 records collected in 2002 and 2003. Nitrogen retention obtained from this study was corrected by 3% to correct for the difference between meat proportion at slaughter and chemic al carcass protein content (no literature reference).

Data are presented in Table 9.6

9.3.1.6 Sheep and goat

No data on N balances are reported. A net N excretion value applied on land is reported (99 kg of N/ton of live weight per year) but the derivation of this figures has not been reported.

Table 9.6. Nitrogen excretion of white veal calf

Item	Unity	Value	Standard deviation	Coefficient of variation
N applied to land	kg/hd/yr	8.6		
	kg/t LW/yr	76		
N balance for heavy pigs				
Intake	kg/head/yr	24.1	1.85	0.077
Retention	kg/head/yr	12.1	0.81	0.067
Excretion	kg/head/yr	11.9	1.52	0.128
Volatilisation	kg/kg	0.28	(correction factor)	
Net excretion	kg/head/yr	8.6	1.10	0.128
Basic data				
Cycles	/yr	2.1	0.13	0.062
Crude protein average feed	kg/kg	0.215	0.011	0.051
Initial live weight at start	kg	61	6.1	0.100
Live weight at slaughter	kg	253	13.9	0.055
Feed conversion fattening period	kg DM/kg LW gain	1.73	0.10	0.058

$If corrected for other pig farming system by extrapolation: 13.61
#Not correct for other pig farming systems and therefore different from N applied to land

9.3.2 Pigs

9.3.2.1 Sows

Table 9.7. Nitrogen excretion of sows and piglets until reaching a live weight of 30 kg

Item	Unity	Value	Standard deviation	Coefficient of variation
N applied to land	kg/hd/yr	26.4		
	kg/t LW/yr	101		
N balance				
Intake	kg/head/yr	55.4	4.0	0.072
Retention	kg/head/yr	18.8	1.8	0.096
Excretion	kg/head/yr	36.6	2.7	0.074
Volatilisation	kg/head/yr	10.2	0.8	0.078
Net excretion	kg/head/yr	26.4	2.9	0.110
Basic data				
Feed intake	kg/sow/yr	1141	97	0.085
Crude protein sow feed	kg/kg	0.15	0.004	0.027
Piglets per sow	n/yr	21.7	2.6	0.120
Piglets live weight at weaning	kg	6.7	0.5	0.075
Piglets live weight at suckling	kg	30.9	3.9	0.126
Feed conversion suckling period	kg/kg	1.85	0.2	0.108
Crude protein suckling feed	kg/kg	0.182	0.004	0.022

Data for sows with piglets until the end of the suckling period (at a live weight of 30 kg) have been obtained from 26 farms in the regions of Veneto and Emilia Romagna. Data collection was performed in 2002 and 2003 and comprised in total 38,770 "sow years". Data are presented per region. From these data the mean value and the standard deviation have been reported (Table 9.7). From these data, it is calculated that the coefficient of variation for nitrogen excretion (36.6 kg/head/yr) is 0.096.

9.3.2.2 Finishing pigs

Data for finishing pigs were collected at 61 representative farms in the regions Veneto and Reggio Emilia. Information on animals and feeds was collected between 1997 and 2003 and comprised 215,000 records. Pigs on these farms were slaughtered at a relatively high live weight, being on average 163.4 kg. It was calculated that these pigs (28.5 to 163.4 kg) excrete 13.81 kg of nitrogen per head per year. Because this high live weight at slaughter is not representative for the Italian pig farming systems a correction was made, assuming 65% of other heavy pigs, 25% of other pig breeds and 10% of the pigs slaughtered at a lighter live weight (average 89 kg). To calculate the N from pig manure applied to land (net nitrogen excretion), a correction is made for nitrogen volatilisation of 28%. The impact for the correction of other breeds and lighter pigs at slaughter seems marginal: extrapolating the calculated net nitrogen excretion (being 9.9 kg) with the published net nitrogen excretion (9.8 kg/hd/yr) to the uncorrected nitrogen excretion, resulted in a correction of 0.2 kg of N/hd/yr. The decree presents the average values from the 215,000 collected records (Table 9.8).

Table 9.8. Nitrogen excretion of finishing pigs

Item	**Unity**	**Value**	**Standard deviation**	**Coefficient of variation**
N applied to land	kg/hd/yr	9.8		
	kg/t LW/yr	110		
N balance for heavy pigs				
Intake	kg/head/yr	19.00	1.87	0.098
Retention	kg/head/yr	5.19	0.46	0.089
Excretion	kg/head/yr	13.81[$]	1.57	0.114
Volatilisation	kg/kg	0.28	(correction factor)	
Net excretion	kg/head/yr	9.94[#]	(calculated)	
Basic data				
Crude protein average feed	kg/kg	0.153	0.007	0.046
Initial live weight at start	kg	28.5	4.7	0.165
Live weight at slaughter	kg	1634	5.3	0.003
Feed conversion fattening period	kg/kg	3.64	0.26	0.071
Cycles/year	Nr.	1.6		
N-content/kg of pig	g/kg	24.0		

[$]If corrected for other pig farming system by extrapolation: 13.61
[#]Not correct for other pig farming systems and therefore different from N applied to land

9.3.3 Poultry

9.3.3.1 Rearing and laying hens

Data for rearing hens are derived from two farms considered to be representative for Italy. Data are derived from 185,000 animals. It was assumed that 80% of the hens are housed in batteries and 20% on floor housing systems. Data for laying hens are derived from 9 representative farms comprising 404,600 hens. Data were collected in 2002 and 2003. Data are presented in Table 9.9

Table 9.9. Nitrogen excretion of rearing and laying hens

Item	**Unity**	**Rearing hens**	**Laying hens, strain**			
			A	**B**	**C**	**D**
N balance						
Intake	kg/head/cycle	0.47	1.14	1.17	1.08	0.97
Retention	kg/head/cycle	0.14	0.36	0.32	0.33	0.31
Excretion	kg/head/yr	0.33	0.78	0.85	0.75	0.66
Volatilisation	kg/kg			0.30		
Net excretion	kg/head/yr	0.23	0.55	0.60	0.53	0.46
Basic data						
Productive cycle	D	118	414	409	395	469
Days empty per cycle	D	14	14	14	14	14
Cycles	/yr	2.8	0.85	0.86	0.89	0.75
Live weight at start	Kg	0.04	1.51	1.34	1.41	1.47
Live weight at end	Kg	1.40	2.05	1.80	1.87	2.15
Egg production	kg/hd/d	-	18.42	15.86	16.24	16.63
N content eggs	kg/kg		0.017	0.017	0.017	0.017
Conversion rate	kg DM/kg LW gain	4.44	2.20	2.51	2.24	2.10
Crude protein feed	kg/kg	0.18	0.169	0.177	0.178	0.169

9.3.3.2 Broilers

Data for broilers have been collected on 7 farms during 2002 and 2003, comprising 205,400 records. Data on carcass composition have been obtained from analyses of carcasses sampled at slaughter houses. It has been assumed that 50% of the broilers are males with an average live weight of 3 kg, while 25% of the broilers are females with an average live weight of 1.7 kg and 25% are females with a live weight of 2.5 kg. Data are presented in Table 9.10.

Table 9.10. Nitrogen excretion of broiler chickens

Item	Unity	Data
N balance		
Intake	kg/head/yr	0.66
Retention	kg/head/yr	0.30
Excretion	kg/head/yr	0.36
Volatilisation	kg/kg	0.30
Net excretion	kg/head/yr	0.25
Basic data		
Cycles	n/yr	4.5
Days empty per cycle	D	14
Live weight at start	Kg	0.04
N content at start	kg/kg live weight	0.025
Live weight at end	Kg	2.4
N content at end	kg/kg live weight	0.030
Conversion rate	kg DM/kg LW gain	2.1
Crude protein feed	kg/kg	0.19

9.3.3.3 Turkey

Data for turkeys have been collected on 4 farms during 2002 and 2003, comprising 22,280 records of male turkey and 19,850 records for female turkey. Data on carcass composition have been obtained from analyses of carcasses sampled at slaughter houses. Data are presented in Table 9.11.

Table 9.11. Nitrogen excretion of turkey

Item	Unity	Male	Female
N balance			
Intake	kg/head/yr	3.38	1.85
Retention	kg/head/yr	1.28	0.82
Excretion	kg/head/yr	2.13	1.03
Volatilisation	kg/kg	0.30	
Net excretion	kg/head/yr	1.49	0.76
Basic data			
Cycles	n/yr	2.2	3.1
Days empty per cycle	d	14	14
Live weight at start	kg	0.061	0.059
N content at start	kg/kg live weight	0.025	0.025
Live weight at end	kg	18	8
N content at end	kg/kg live weight	0.0324	0.0326
Conversion rate	kg DM/kg LW gain	2.6	2.16
Crude protein feed	kg/kg	0.22	0.22

9.4 Assessment

9.4.1 Complexity of methodology

The Italian methodology uses the nutrient balance method to calculate standard excretion coefficients for a number of animal categories. For each animal category default values for feed intake and feed composition are derived from a set of representative practical farms. Nutrient deposition is based on (inter)national literature reviews.

9.4.2 Strength and weakness

The nitrogen excretions standards have been derived from nitrogen balance measurements on farm level at a number of farms in different regions. Although nitrogen balances of livestock animals may vary between regions, the decree presents average values for nitrogen excretion per animal category. It is not well documented how this average is calculated since no other information or reports have been obtained on the design and individual results of these farm balance measurements. Thus, the origin of the data is not very transparent.

10 The Netherlands

10.1 Methodology

The methodology for calculation of standard data of nitrogen (N) and phosphorus (P) excretion is based on a system described by Statistics Netherlands (CBS, 2012) and by the CBS Working group on uniformity of calculations of manure and mineral data (WUM, 1994a,1994b, 1994c). The method used is a balance method at animal category level and calculates the mineral excretion on animal level for a 365 days period. The excretion is calculated by subtracting mineral deposition in animals and animal products from mineral intake with feed. The N and P excretion standards are expressed in kg N and P per animal per year. The national and farm manure production is calculated as the sum of the individual animal excretions. To convert excretion standards into manure production the N excretion standards are corrected for volatilisation losses during storage (NH_3, N_2 and N_2O). For volatilisation losses also standards are used. These standards differ with animal category and housing- and storage system. The calculation method and the calculated standards are a responsibility of a scientific committee (CDM). Table 10.1 gives data of dairy cattle as an example of this calculation method.

Table 10.1. Example of the calculation method for excretion standards: dairy cattle (kg per animal per year for slurry).

	Excretion ex animal		Volatilisation losses		Net excretion		Standard	
	N	P_2O_5	N	P_2O_5	N	P_2O_5	N	P_2O_5
Dairy cow	136,7	42,6	16,1	0	120,6	42,6	114,6	40,5
Young stock < 1 yr	39,2	10,2	2,3	0	36,9	10,2	35,1	9,7
Young stock > 1 yr	75,2	23,5	5,0	0	70,2	23,5	66,7	22,3
Suckler cow	84,1	28,6	9,2	0	74,9	28,6	71,2	27,2
Breeding bull > 2 yr	89,0	26,5	12,3	0	76,7	26,5	72,9	25,2

10.2 Animal categories

Two main categories of animals are distinguished: grazing animals and housed animals. Grazing animals (ruminants) are defined as animals fed diets with substantial amounts of roughages, while the way these animals are housed is not considered to be relevant (cattle, rosé calves, sheep, goats, horses, donkeys, Mid-European red deer, deer (fallow) and water buffalo).
Housed animals are defined as animals fed diets mainly consisting of concentrates and purchased (by)products (veal calves, pigs, chickens, turkeys, Peking duck, mink, fox, ostrich, emoe, nandoe, geese, guinea fowl, pheasant, partridge, pigeon, rabbits and other rodents).

10.3 Data origin

Data concerning feed intake and animal production are collected by the WUM working group of CBS. The parliament decided that the excretion standards have to be based on the actual excretion of the average Dutch farm (KST28385, 2004). These farm data are yearly collected. The current working group consists of representatives of the following institutions: Statistics Netherlands (CBS), Dutch Ministry of Economic Affairs (formerly the Dutch Ministry of Agriculture, Nature and Food Quality – Directorate Knowledge and Innovation), LEI Wageningen UR, PBL Netherlands Environmental Assessment Agency, National Institute for Public Health and the Environment (RIVM) and Livestock Research Wageningen UR.
The annual standard data represent average factors on a national level and reflect the nutrient excretions per animal for particular calendar years. Multiplied with animal numbers the standards result in a national manure production and nutrient excretions. The standard data are determined according to a standard protocol for calculation and data collection. These standard data are updated on an annual basis and become available in October of the next year. However, animal categories with little or no effect on the national nutrient excretions are not annually updated.

Technical index numbers are used for data on feed use (concentrate feed and roughage) and animal production (milk, eggs, animal growth, and numbers of animals). In addition, data are required on N and P content in feed and animal products. A distinction is made between annually updated index numbers and 'fixed' numbers. The index numbers to be updated annually are derived as much as possible from statistics and technical administrations (LEI-Wageningen UR; CBS, a,b,c; Agrovision; OPNV). The 'fixed' index numbers are constant for a number of years and are based on studies on average nitrogen and phosphorous excretions per animal category. These studies are conducted regularly (Hoek van der 1987; Heeres-van der Tol, 2001; Tamminga et al., 2000, 2004 and 2009; Jongbloed and Kemme, 2005, Kemme et al.,2005a and 2005b) and collect large amounts of information on fixed index numbers that subsequently are applied by the WUM.

Table 10.2. N and P excretion grazing animals cattle, sheep and goats

		type	Excretion in kg / animal / year		
	Age	manure	corrected for volatilisation		
Cattle			N	P	P_2O_5
dairy cow			Table 10.3a,b		Table 10.3b
young stock < 1 year		slurry	35,1	4,2	9,7
		solid	29,9	4,2	9,7
young stock > 1 year		slurry	66,7	9,7	22,3
		solid	56,9	9,7	22,3
veal calf	14 days- 6 months		8,3	-	-
calf rosé	14 days- 8 months		18,4	3,6	8,3
calf rosé	14 days- 3 months		8,8	1,1	2,6
calf rosé	3 - 6 months		23,6	5,0	11,4
starter calf red	14 days- 3 months		8,8	1,1	2,6
Fattening bulls	3 - 24 months	slurry	32,3	5,2	11,8
		solid	29,3	5,2	11,8
suckler cow		slurry	71,2	11,9	27,2
		solid	63,5	11,9	27,2
breeding bull			72,9	11,0	25,2
Sheep					
breeding ewe			10,2	1,6	3,6
other sheep			7,4	1,0	2,4
Goats					
dairy goat			5,8	1,6	3,6
fattening kid			0,5	0,1	0,3
other goats			3,1	1,0	2,3

10.3.1 Grazing animals

The feed nutrient content and nutritional values are updated annually for most categories of cattle, sheep and goats. In addition, for dairy cows also the composition of feed rations and nutrient deposition in animal products are updated annually.

Feed intake
Cattle, sheep and goats generally eat raw feed materials, supplemented with concentrate feed in the form of compound feed. In addition, they could be fed moist concentrate feed that consists mainly of waste products from the food industry. To calculate the amount of ingested feed, feeding losses are included: 2% for concentrate feeds, 3% for moist concentrate feeds and 5% for ensilaged raw feeds.

Roughages
For dairy cows the amounts of annually used grass silage and hay were derived from harvest yields and stock mutations, based on the CBS study into grassland use. The annually used maize silage is calculated from the amounts harvested (CBS), minus preservation losses of 5% and are corrected according to stock mutations, based on information derived from the Farm Accountancy Data Network (BIN) of the LEI Wageningen UR (*Bedrijven Informatie Net* (BIN)). General data for meadow grass intake are not available. Therefore, meadow grass intake is calculated as the remaining energy requirements when energy supplementation by all other feeds consumed are subtracted from energy requirements as suggested by Tamminga et al. (2004) (CBS, 2009). For the other categories of ruminants feed intake is based on feed requirements. For each animal category the average diet fed to meet the energy requirements are derived from extensive studies and are fixed for a longer period. the N and P contents of the feeds in the diets are updated annually as for dairy cows.

Compound feeds and other purchased feeds
For grazing animals, compound feed suppliers are not obliged to report to the *Dienst Regelingen* on deliveries of compound feeds. Therefore, nutrient uptake for the cattle categories can not be calculated from registered feed deliveries. However, data are available on compound feed sales in terms of amounts of intestinally digestible protein (DVE). These data were subsequently grouped by the categorisation used in feed value pricing to determine nutrient content. For rations of beef cattle categories, fixed amounts of starter feed and finishing feed were used. The composition of starter and finishing feeds is occasionally obtained from a number of compound feed producers.
Data on the use of raw feed materials, since 2002, have been obtained from the BIN database (*Bedrijven Informatienet*) of the LEI Wageningen UR. Sales of moist concentrate feeds are mapped annually by the OPNV (discussion group of moist livestock feed producers '*Overleggroep Producenten Natte Veevoeders'* (OPNV)). In the composition of moist concentrate feeds a distinction has been made between the moist concentrate feed for calves in pink-meat production plus beef bulls and moist concentrate feed for other cattle (Kemme et al., 2005a). For data on sales of moist concentrate feeds for cattle, a certain amount of losses from preservation have been taken into account (CBS, 2009).

N and P contents in feeds
Roughage composition is based on annual data from the laboratory on soil and crop research in Oosterbeek (*BLGG*). For hay feed values are kept at a set level, as the share of hay in rations is relatively small. The N content in low-fertilised meadow grass is been assumed to be 20% lower than that of regular meadow grass. The N content in grass silage from extensively managed grassland was set at 10% below that of regular meadow grass (Tamminga et al., 2004).

Nutrient deposition
Nutrient deposition in animals and animal products are derived from statistical data, whenever possible. Data on cow milk production is the only parameter that is updated on an annual basis. Data on live weights of grazing animals are updated occasionally. New data on N and P content in grazing animals only rarely become available.

Milk production per cow was calculated from data on total national milk production and the number of dairy cows and are based on data from the Dutch Dairy Board, including additional estimations of dairy production not supplied to dairy factories.

10.3.1.1 Dairy cows

For dairy cows the variation of the average excretion is large. Therefore a further differentiation of the standards was provided. This differentiation takes into account the milk production level (kg milk per cow per year) and for N excretion also the milk urea content (annual average of the herd). The latter is used as indicator for low feed protein inputs. The differentiated excretions are derived using the following formulas (the excretion is including a correction for N volatilisation of 11,8% for slurry and 20% for solid manure)

N excretion (kg N/animal/year) slurry = 0,882(129,9+0,0089*(milk-7744) + 1,7*(urea-26))*

N excretion (kg N/animal/year) solid = 0,800(129,9+0,0089*(milk-7744) + 1,7*(urea-26))*

P_2O_5 *excretion (kg N/animal/year) = 40,5+0,0028*(milk-7744)*

An example of this differentiation is provided for dairy cows in a slurry system (Tables 10.3a and b).

Table 10.3a. Nitrogen excretion in a slurry system, differentiated by milk production and milk urea content (in kg N/cow/year, corrected for volatilisation) for dairy cows.

	Nitrogen																	
Milk production	**Milk urea (mg urea per 100 ml milk)**																	
	< 14	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
< 5.624	75,0	76,5	78,0	79,5	81,0	82,5	84,0	85,5	87,0	88,5	90,0	91,5	93,0	94,5	96,0	97,5	99,0	100,5
5.625 - 5.874	79,5	81,0	82,5	84,0	85,5	87,0	88,5	90,0	91,5	93,0	94,5	96,0	97,5	99,0	100,5	102,0	103,5	105,0
5.875 - 6.124	81,5	83,0	84,5	86,0	87,5	89,0	90,5	92,0	93,5	95,0	96,5	98,0	99,5	101,0	102,5	104,0	105,5	107,0
6.125 - 6.374	83,5	85,0	86,5	88,0	89,5	91,0	92,5	94,0	95,5	97,0	98,5	100,0	101,5	103,0	104,5	106,0	107,5	109,0
6.375 - 6.624	85,5	87,0	88,5	90,0	91,5	93,0	94,5	96,0	97,5	99,0	100,5	102,0	103,5	105,0	106,5	108,0	109,5	111,0
6.625 - 6.874	87,0	88,5	90,5	92,0	93,5	95,0	96,5	98,0	99,5	101,0	102,5	104,0	105,5	107,0	108,5	110,0	111,5	113,0
6.875 - 7.124	89,0	90,5	92,0	93,5	95,0	97,0	98,5	100,0	101,5	103,0	104,5	106,0	107,5	109,0	110,5	112,0	113,5	115,0
7.125 - 7.374	91,0	92,5	94,0	95,5	97,0	98,5	100,5	101,5	103,0	105,0	106,5	108,0	109,5	111,0	112,5	114,0	115,5	117,0
7.375 - 7.624	93,0	94,5	96,0	97,5	99,0	100,5	102,0	103,5	105,0	106,5	108,0	109,5	111,0	113,0	114,5	116,0	117,5	119,0
7.625 - 7.874	95,0	96,5	98,0	99,5	101,0	102,5	104,0	105,5	107,0	108,5	110,0	111,5	113,0	114,5	116,0	117,5	119,0	121,0
7.875 - 8.124	97,0	98,5	100,0	101,5	103,0	104,5	106,0	107,5	109,0	110,5	112,0	113,5	115,0	116,5	118,0	119,5	121,0	122,5
8.125 - 8.374	99,0	100,5	102,0	103,5	105,0	106,5	108,0	109,5	111,0	112,5	114,0	115,5	117,0	118,5	120,0	121,5	123,0	124,5
8.375 - 8.624	101,0	102,5	104,0	105,5	107,0	108,5	110,0	111,5	113,0	114,5	116,0	117,5	119,0	120,5	122,0	123,5	125,0	126,5
8.625 - 8.874	103,0	104,5	106,0	107,5	109,0	110,5	112,0	113,5	115,0	116,5	118,0	119,5	121,0	122,5	124,0	125,5	127,0	128,5
8.875 - 9.124	105,0	106,5	108,0	109,5	111,0	112,5	114,0	115,5	117,0	118,5	120,0	121,5	123,0	124,5	126,0	127,5	129,0	130,5
9.125 - 9.374	107,0	108,5	110,0	111,5	113,0	114,5	116,0	117,5	119,0	120,5	122,0	123,5	125,0	126,5	128,0	129,5	131,0	132,5
9.375 - 9.624	109,0	110,5	112,0	113,5	115,0	116,5	118,0	119,5	121,0	122,5	124,0	125,5	127,0	128,5	130,0	131,5	133,0	134,5
9.625 - 9.874	111,0	112,5	114,0	115,5	117,0	118,5	120,0	121,5	123,0	124,5	126,0	127,5	129,0	130,5	132,0	133,5	135,0	136,5
9.875 - 10.124	113,0	114,5	116,0	117,5	119,0	120,5	122,0	123,5	125,0	126,5	128,0	129,5	131,0	132,5	134,0	135,5	137,0	138,5
10.125 - 10.374	115,0	116,5	118,0	119,5	121,0	122,5	124,0	125,5	127,0	128,5	130,0	131,5	133,0	134,5	136,0	137,5	139,0	140,5
10.375 - 10.624	117,0	118,5	120,0	121,5	123,0	124,5	126,0	127,5	129,0	130,5	132,0	133,5	135,0	136,5	138,0	139,5	141,0	142,5
> 10.624	120,5	122,0	123,5	125,0	126,5	128,5	130,0	131,5	133,0	134,5	136,0	137,5	139,0	140,5	142,0	143,5	145,0	146,5

Table 10.3b. Nitrogen excretion of dairy cows in a slurry system, differentiated by milk production and milk urea content (in kg N/cow/year, corrected for volatilisation) and phosphate excretion (kg/cow/year)

	Nitrogen											P_2O_5
Milk production	Milk urea (mg urea per 100 ml milk)											
	31	32	33	34	35	36	37	38	39	40	> 40	
< 5.624	102,0	103,5	105,0	106,5	108,0	109,5	111,0	112,5	114,0	116,0	117,5	33,5
5.625 - 5.874	106,5	108,0	109,5	111,0	112,5	114,0	115,5	117,0	118,5	120,0	121,5	35,0
5.875 - 6.124	108,5	110,0	111,5	113,0	114,5	116,0	117,5	119,0	120,5	122,0	123,5	35,7
6.125 - 6.374	110,5	112,0	113,5	115,0	116,5	118,0	119,5	121,0	122,5	124,0	125,5	36,4
6.375 - 6.624	112,5	114,0	115,5	117,0	118,5	120,0	121,5	123,0	124,5	126,0	127,5	37,1
6.625 - 6.874	114,5	116,0	117,5	119,0	120,5	122,0	123,5	125,0	126,5	128,0	129,5	37,7
6.875 - 7.124	116,5	118,0	119,5	121,0	122,5	124,0	125,5	127,0	128,5	130,0	131,5	38,4
7.125 - 7.374	118,5	120,0	121,5	123,0	124,5	126,0	127,5	129,0	130,5	132,0	133,5	39,1
7.375 - 7.624	120,5	122,0	123,5	125,0	126,5	128,0	129,5	131,0	132,5	134,0	135,5	39,8
7.625 - 7.874	122,5	124,0	125,5	127,0	128,5	130,0	131,5	133,0	134,5	136,0	137,5	40,5
7.875 - 8.124	124,0	125,5	127,5	129,0	130,5	132,0	133,5	135,0	136,5	138,0	139,5	41,2
8.125 - 8.374	126,0	127,5	129,0	130,5	132,0	133,5	135,5	137,0	138,5	140,0	141,5	41,9
8.375 - 8.624	128,0	129,5	131,0	132,5	134,0	135,5	137,0	139,0	140,0	141,5	143,5	42,6
8.625 - 8.874	130,0	131,5	133,0	134,5	136,0	137,5	139,0	140,5	142,0	143,5	145,0	43,2
8.875 - 9.124	132,0	133,5	135,0	136,5	138,0	139,5	141,0	142,5	144,0	145,5	147,0	43,9
9.125 - 9.374	134,0	135,5	137,0	138,5	140,0	141,5	143,0	144,5	146,0	147,5	149,0	44,6
9.375 - 9.624	136,0	137,5	139,0	140,5	142,0	143,5	145,0	146,5	148,0	149,5	151,0	45,3
9.625 - 9.874	138,0	139,5	141,0	142,5	144,0	145,5	147,0	148,5	150,0	151,5	153,0	46,0
9.875 - 10.124	140,0	141,5	143,0	144,5	146,0	147,5	149,0	150,5	152,0	153,5	155,0	46,7
10.125 - 10.374	142,0	143,5	145,0	146,5	148,0	149,5	151,0	152,5	154,0	155,5	157,0	47,4
10.375 - 10.624	144,0	145,5	147,0	148,5	150,0	151,5	153,0	154,5	156,0	157,5	159,0	48,1
> 10.624	148,0	149,5	151,0	152,5	154,0	155,5	157,0	158,5	160,0	161,5	163,0	49,4

10.3.1.2 Other grazing animals

Table 10.4. Nitrogen and P excretion coefficient of other grazing animals

		Excretion in kg / animal / year		
	Age	corrected for volatilisation		
		N	P	P_2O_5
Horses				
pony < 250 kg	> 6 months	17,4	3,3	7,5
pony 250 - 450 kg	> 6 months	29,7	6,2	14,2
horse 250 -450 kg	> 6 months	36,6	7,6	17,5
horse > 450 kg	> 6 months	47,6	9,6	22,0
Donkey				
all categories	> 6 months	19,3	3,5	8,0
Red deer				
female + calf	calf < 6 months	17,7	2,8	6,4
fattening deer	6 - 12 months	8,1	1,2	2,7
fattening deer	> 12 months	20,3	2,7	6,1
Fallow deer				
female + calf	calf < 3 months	11,2	1,4	3,2
fattening deer	> 3 months	9,2	1,0	2,3
Water buffalo				
Dairy cows		72,7	12,4	28,4
young stock	< 2 years	27,2	4,2	9,6

10.3.2 Pigs

For pigs, the following animal categories are distinguished: growing-finishing pigs, rearing gilts and boars (<50 and >50 kg), breeding sows with nursery piglets <25 kg body weight and breeding boars. Feed usage and animal performance are derived from an annually updated database of approximately 1100 sows farms and 1400 pigs farms collected by Agrovision BV. This dataset includes a representative number of farms using wet liquid products. The use of liquid diets is recalculated on the basis of dry matter content. Data of feed use are not corrected for feed spillage since this spillage is often collected together with the manure. Feed intake and performance of rearing gilts and boars and breeding boars are not available in this database and not collected at a regular basis. Excretion factors for these animal categories are assumed constant and only periodically updated, based on scientific and practical data. At present, Jongbloed and Kemme (2005) is the major source of information for these categories.

Since 2004, mineral content in compound feed is derived from data registered by the "Dienst Regelingen" of the Dutch government. N and P content of all compound feed is registered, although not specifically for the individual animal categories. However, the average composition (N and P content) of diets per animal categories is calculated by combination of CBS statistical data regarding the type and number of animals per farm and the amount and N and P content of diets annually used on individual farms. The values for N and P content of compound feeds and feed ingredients are supplied by the feed suppliers and are based on table values and chemical analysis. The total annual use of liquid by-products for pigs is registered by a platform of suppliers of these feeds (OPNV). The N and P content of these products is derived from the national Dutch table with composition of feed ingredients (CVB).

The amount of N and P retained in pigs depends on the body retention (kg) and the contents in body tissue. The body retention is derived from initial and final body weight of animals in the respective category, based on Agrovision data for sows, piglets and growing-finishing pigs. The contents in body tissue are periodically updated on the basis of Dutch studies using carcass grinding and analysis and relevant studies published in scientific literature. At present, values in body tissue are largely based on Jongbloed et al., (2002a,b) as summarised by WUM (2010). Mineral retention is calculated as (end weight × mineral content)-(initial weight × mineral content).
Table 10.5 provides the N and P contents in different categories of pigs (Jongbloed and Kemme, 2005)

Table 10.5. The N and P contents (g/kg live weight) in different categories of pigs (Jongbloed and Kemme, 2005)

Category	Estimated weight (kg)	Age/ Physiological state	N-content (g/kg)	P-content (g/kg)
Dead born piglet	1.3	0 days	18.7	6.15
Culled piglet	2.8	1 – 28 days	23.1	5.36
Culled piglet	9.0	29 – 42 days	24.3	5.35
Weaned piglet	11.0	6 weeks	24.4	5.33
Culled piglet	12.0	7 weeks	24.5	5.33
Growing pig	26	10 weeks	24.8	5.32
Finishing pig	114	26 weeks	25.0	5.36
Rearing sow	125	7 months	24.9	5.35
Rearing sow	140	First mating	24.9	5.35
Rearing boar	135	7 months	24.9	5.35
Boar (breeding)	325	2 years	25.0	5.35
Breeding sow	220	At weaning	25.0	5.35
Sow at slaughter	220	1 wk after weaning	25.0	5.35

The N and P contents of the different categories of pig diets are provided in Table 10.6.

Table 10.6 N and P contents (g/kg) in different categories of pig diets (Jongbloed and Kemme, 2005)

Category	N-content	P-content
Starter diet weanling pigs	27.0	5.5
Grower diet weanling pigs (12-26 kg)	27.9	5.3
Starter diet growing finishing pigs (26–30 kg)	27.1	4.7
Grower diet growing finishing pigs (30–70 kg)	26.2	4.8
Finisher diet (70–114 kg)	23.6	4.6
Rearing sow diet (26–125 kg)	24.5	5.0
Standard sow diet	23.8	5.4
Lactating sow diet	24.5	5.7
Gestating sow diet	20.4	5.0

Table 10.7 provides the N and P balance for the different pig categories.

Table 10.7 N and P balance for the different pig categories on a year base (Jongbloed and Kemme, 2005)

Category	Feed intake (kg)	N intake (kg)	P intake (kg)	N deposition (kg)	P deposition (kg)	N excretion (kg)	P excretion (kg)[1]	N Forfait[2] (kg)	P Forfait[2] (kg)
Sow incl. piglets (6 wk of age)	1273	28.39	6.71	7.68	1.69	20.9	5.02 (11.50)	21.4	4.81
Sow incl. piglets (25 kg BW)	1904	46.01	10.16	16.88	3.73	29.1	6.43 (14.72)	28.1	6.29
Breeding sow (25 kg – 7 month)	788	19.40	3.93	6.77	1.46	12.6	2.47 (5.66)	11.4	2.53
Breeding sow (7 month– 1st mating)	876	21.46	4.99	4.54	0.98	16.9	4.02 (9.21)	16.2	3.67
Breeding sow (25 kg – 1st mating)	804	19.78	4.12	6.36	1.37	13.4	2.75 (6.30)	11.8	2.62
Boar (breeding) (25 kg – 7 month)	796	19.54	3.71	7.45	1.60	12.1	2.11 (4.83)	11.0	2.49
Boar (breeding) (7 month or older)	1095	26.83	6.24	3.18	0.68	23.6	5.56 (12.73)	21.1	4.89
Piglets (6 wk of age – 25 kg)	249	6.95	1.32	3.57	0.75	3.38	0.57 (1.31)	3.29	0.70
Sow at slaughter	1095	26.83	6.24	0	0	26.8	6.24 (14.29)	20.9	4.85
Growing–finishing pig (25 – 114 kg)	729	17.97	3.40	7.07	1.52	10.9	1.88 (4.31)	11.7	2.01

[1]) Phosphate excretion between brackets.

[2]) LNV (2004)

10.3.3 Poultry

For poultry, the following seven animal categories are distinguished: rearing hens and laying hens, broiler breeder pullets and broiler breeder, broilers, turkeys and ducks. Feed use and animal production performance of broilers and laying hens are based on annually updated data of a representative selection of 30-35 farms for each category (BIN, bedrijven informatienet) collected by LEI (Agricultural Economics Research Institute). Additional information for laying hens, e.g. regarding final weight and length of the production period are annually updated on the basis of KWIN-V (Quantitative information animal husbandry). Feed intake and performance of other categories: rearing hens, broiler breeders, turkeys and ducks, are not available in this database and not collected at a regular basis. Excretion factors for these animal categories are assumed constant and only periodically updated, based on scientific and practical data. At present, Jongbloed and Kemme (2005) is the major source of information for these categories whereas De Buisonjé et al. (2009) is the basis for ducks. Some characteristics for these categories are derived from KWIN-V (Quantitative information animal husbandry) and annually updated.

The mineral content of poultry diets is largely based on data registered for compound feeds and feed ingredients supplied to poultry farms by Dienst Regelingen, as previously described for pigs. The amount of N and P retained in animal products depends on egg production and body retention (kg) and the contents in eggs and body tissue. Following the same method as in pigs, body mineral retention in broilers is based on weight gain according to LEI-BIN data and tissue content according to Coppoolse et al., 1990 and Versteegh en Jongbloed (2000a en b). Mineral retention in eggs and body tissue in laying hens is based on data of egg production (LEI-BIN), body mass (KWIN-V) and tissue content according to Coppoolse et al. (1990) and Jongbloed and Kemme (2002b). Mineral retention in the other categories are based on performance data from Jongbloed and Kemme (2005) and De Buisonjé et al. (2009) and mineral content by a variety of references as summarised by WUM (2010).

Table 10.8 provides the N and P contents in different categories of poultry (Jongbloed and Kemme, 2005)

Table 10.8 The N and P contents (g/kg live weight) in different categories of poultry (Jongbloed and Kemme, 2005)

Category	Weight (g)	Age/ Physiological state	N-content (g/kg)	P-content (g/kg)
Egg broiler breeder	62	-	19.3	1.9
Day-old broiler pullet	42	1 day	30.4	3.4
Broiler	2100	Slaughter	27.8	4.4
Broiler breeder hen	2000	≥19 weeks	33.4	4.9
Broiler breeder male	2750	≥19 weeks	34.5	5.4
Egg laying hen	62.5	-	18.5	1.7
Day-old hen pullet	35	1 day	30.4	3.4
Laying hen	1900	≥18 weeks	28.0	5.6

The N and P contents of the different categories of poultry diets are provided in Table 10.9.

Table 10.9 N and P contents (g/kg) in different categories of poultry diets (Jongbloed and Kemme, 2005)

Category	N-content	P-content
Laying hen diet phase 1	24.9	4.8
Laying hen diet phase 2	24.5	4.6
Laying hen diet phase 3	23.2	4.3
Rearing hen diet phase 1	28.3	5.9
Rearing hen diet phase 2	23.7	5.6
Pre-lay broiler breeder diet	24.1	4.5
Broiler breeder diet	23.6	4.4
Broiler diet phase 1	34.6	6.2
Broiler diet phase 2	32.0	5.0
Broiler diet phase 3	30.9	4.6

Table 10.10 provides the N and P balance for the different poultry categories.

Table 10.10 N and P balance for the different poultry categories on a year base (Jongbloed and Kemme, 2005)

Category	Feed intake (kg)	N intake (kg)	P intake (kg)	N deposition (kg)	P deposition (kg)	N excretion (kg)	P excretion (kg)[1]	N Forfait[2] (kg)	P Forfait[2] (kg)
Male and female rearing hens (<18 weeks)	18.0	0.453	0.103	0.128	0.025	0.325	0.077 (0.176)	---	---
Laying hens (≥ 18 weeks)	44.5	1.080	0.206	0.354	0.033	0.726	0.172 (0.394)	0.900	0.218
Broiler breeder pullets (< 19 weeks)	20.7	0.514	0.118	0.200	0.030	0.314	0.088 (0.202)	0.414	0.095
Male and female Broiler breeders (≥ 19 weeks)	52.8	1.249	0.233	0.261	0.034	0.988	0.199 (0.456)	1.130	0.253
Broilers	31.5	0.999	0.155	0.501	0.080	0.498	0.075 (0.172)	0.498	0.089

[1]) Phosphate excretion between brackets.
[2]) LNV (2004)

10.4 Assessment

10.4.1 Complexity of the methodology

Recently the Dutch method for calculation of N and P excretion was evaluated by a committee of experts (CDM, 2012). The committee concluded that the method is complex, scientifically sound, well documented and transparent. The calculated excretion is accurate for the major species (cattle, pigs, laying hens, broilers) and may be less accurate for minor species because of uncertainties with regard to farming systems, feed use and N and P content of animals. The databases used to calculate the N and P excretion are not specifically developed for this purpose, but the best available in The Netherlands (CDM, 2012).

10.4.2 Strength and weakness

The strength of the Dutch system is that it is transparent and well documented.

The total number of animals in each category is based on national statistics (CBS, Landbouwtelling) and an accurate estimate of the total national herd size. Feed intake is estimated for each animal (sub)category and the accuracy of the methods used is evaluated. For the main animal categories the accuracy of the estimated feed intake is good.
The feed intake, growth performance and production of piglets is based on a large database of 1400 grow-finish farms and 1100 sow farms (Agrovision B.V.). This database is not specifically intended for the calculation of excretion and it is not a stratified sample of the total number of pig farms. Nonetheless, because of the large number of farms it is assumed that it is representative for the total Dutch pig production.
Feed intake, growth performance and egg production of laying hens and broilers is based on a stratified sample of 30-35 farms with laying hens and a similar number with broilers under responsibility of LEI. Although the sample size, number of farms, is relatively small, due to stratification the this sample is representative for the total Dutch poultry sector (Vrolijk et al., 2010).
The feed use for pigs and poultry, based on the afore mentioned methods has been compared with the total production of the Dutch compound feed industry, as registered by FEFAC and supply of single feedstuffs and liquid by-products to farm. Additionally, a comparison has been made with data of farm supply of feeds as registered by Dienst Regelingen. The other two datasets agree well with the described calculation method. Production of feed according to FEFAC is 5-10% higher, but this can largely be explained by export of compound feed. Hence the calculated feed use is a good estimate of the Dutch situation (WUM, 2010).
In poultry, calculated feed use is 10-15% higher than the production of compound feed according to FEFAC. This difference may be explained by the use of single feedstuffs, mainly wheat on poultry farms (WUM, 2010).
Actual data of all batches of compound feed as supplied to farms are registered by Dienst Regelingen and are used to calculate the mean content of feed for each animal category. This is considered as an accurate and reliable method.

A weakness is the estimate of amount and composition of liquid feed supplied to different animal categories. However, in the near future, this can presumably be derived from the data registered by Dienst Regelingen (Van Bruggen, pers. comm. 2013).
Data for feed use and production performance could be less accurate and not annually updated for minor animal categories: rearing pigs and breeding boars, broiler breeders, ducks, and turkeys since for these categories no databases similar to Agrovision and LEI-BIN are available. Results of these categories are periodically updated in 5-10 year periods. However, this weakness of the Dutch system has minor consequences on the excretion coefficients, because these categories produce less than 10% of the pig and poultry excretion.

Another weakness are the used N and P content of animal products. They are based on relatively old (5-20 years) documented scientific reports of experts of national institutes in animal science. These reports are based on experiments including grinding and analysis of animals (carcasses) and eggs. Reports include a comparison with relevant scientific literature.

Although these methods can be considered as scientifically sound, for a number of categories reports were published 5-20 years ago. A regular update of these data on N and P content in animals and products, especially for the major animal categories, would improve the accuracy of the calculated excretions. Furthermore, due to the nature of this cost and labour intensive research, relatively small scale studies with specific genotypes and experimental conditions are extrapolated to a large variety of farm situations.

For ruminants the estimation of intake of meadow grass is a weakness, since accurate research data are not available not on intake nor on N and P content. Meadow grass intake is calculated as a remnant category containing all inaccuracies. In order to evaluate the accuracy of this approach, gross grassland production based on calculated feed intake was compared with annual production amounts in the Dutch handbook for dairy farmers (*Handboek Melkveehouderij*). The comparison showed reasonable similarity keeping in mind that gross grassland production was calculated from feed intake by adding feed production and preservation losses of 20%.

11 Poland

11.1 Methodology

The nitrogen excretion for cattle, horses and swine in Poland will be calculated with the use of the SFOM model. Based on quantity, type and digestibility of applied feed ingredients, the manure production will be determined for livestock categories and sub-groups. Then, the nitrogen content in the manure was assessed, based on manure management systems of collection and storage (Jadczyszyn et al., 2000). For goats, the weighted mean value estimated for sheep over the period 1988-2009 was used. The nitrogen excretion of poultry was described by Jadczyszyn (2009). Nitrogen excretion values were summarized in Poland's National Inventory Report (2011).

11.2 Animal categories

The animal categories are summarized in Table 11.1

11.3 Data origin

11.3.1.1 Grazing animals

Table 11.1 Nitrogen excretion values of grazing animals per animal place per year (National Centre for Emission Management (KOBiZE), 2011)

Animal species	*Category*	Production kg N/place/y
Dairy Cattle	Up to 3500 kg milk/cow/year	70.30
	3500 – 4000 kg milk/cow/year	75.90
	4000 – 6000 k milk/cow/year	86.70
	Above 6000 kg milk/cow/year	119.30
Non-dairy cattle	Calves (0 – 3 months)	4.09
	Calves (3 – 6 months)	8.64
	Heifers (6 – 12 months)	22.20
	Heifers (12 – 24 months)	42.40
	Bulls (6 – 18 months)	22.80
	Bulls (> 24 months)	45.70
Sheep	Lambs (6 – 12 months)	3.81
	Sheep (> 1 year)	7.63
Goats		6.70
Horses	Light weight horses	26.16
Horse	Heavy weight horses	29.2

No data regarding phosphorus excretion in Poland is available.

11.3.1.2 Pigs

The N and P contents (g/kg live weight) in different categories of pigs in Poland are shown in Table 11.2.

Table 11.2 The N and P contents (g/kg live weight) in different categories of pigs in Poland

Category	Estimated weight (kg)	Age/ Physiological state	N-content of live weight (g/kg)	P-content (g/kg)
Weaned piglets	20 - 30	?	?	?
Growing pigs	30 - 70	?	?	?
Finishing pig	70 - 110	?	?	?
Sows		?	?	?
Sows with 18 litters		?	?	?

The N contents of the different categories of pig diets in Poland are provided in Table 11.3. The P contents of the different diets are not available yet.

Table 11.3 N and P contents (g/kg) in different categories of Polish pig diets

Category	N-content	P-content
Weaned piglets (20 – 30 kg)	?	?
Growing pigs (30 – 70 kg)	?	?
Finishing pig (70 – 110 kg)	?	?
Sows	?	?
Sows with 18 litters	?	?

Table 11.4 provides the N excretion values for the different pig categories in Spain.

Table 11.4 Nitrogen excretion values of pigs per animal place per year (National Centre for Emission Management (KOBiZE), 2011)

Category	Production (kg N/place/y)
Weaned piglets (20 – 30 kg)	6.69
Growing pigs (30 – 70 kg)	14.76
Finishing pig (70 – 110 kg)	14.76
Sows	15.50
Sows with 18 litters	37.20

No data regarding phosphorus excretion in Poland is available yet.

11.3.1.3 Poultry

Table 11.5 provides the different poultry categories that are distinguished in Poland. N and P contents per kg of live weight are not available yet.

Table 11.5 The N and P contents (g/kg live weight) in different categories of poultry in Spain

Category	Estimated Weight (kg)	Age/ Physiological state	N-content of live weight (g/kg)	P-content (g/kg)
Laying hens	?	?	?	?
Broilers	?	?	?	?
Turkeys	?	?	?	?
Ducks	?	?	?	?
Geese	?	?	?	?

The N contents of the different categories of pig diets in Poland are provided in Table 11.6. The P contents of the different diets are not available yet.

Table 11.6 N and P contents (g/kg) in different categories of Polish poultry diets

Category	N-content	P-content
Laying hens	?	?
Broilers	?	?
Turkeys	?	?
Ducks	?	?
Geese	?	?

Table 11.6 provides the N excretion values for the different poultry categories in Poland.

Tabel 11.6 Nitrogen excretion values of poultry per animal place per year (National Centre for Emission Management (KOBiZE), 2011)

Category	Production (kg N/place/y)
Laying hens	0.382
Broilers	0.262
Turkeys	0.916
Ducks	0.408
Geese	0.447

No data regarding phosphorus excretion in Poland is available.

11.4 Assessment

11.4.1 Complexity of the methodology

The Polish approach is not very complex, since it is based on general standards for manure production and manure composition (N and P) for a limited number of animal categories.

11.4.2 Strength and weakness

The strength of the Polish approach is transparency and strong relationship with animal numbers resulting in relatively low variation in excretion coefficients between years. The weakness is inherent to the methodology e.g. based on estimations of manure production and contents in manure. The average feed composition and the average manure production have large variation, because they depend on many factors (e.g. diet composition, water consumption, environmental conditions and housing system). Moreover, because of N volatilisation, determination of the N content of manure varies with time after defecation.

It is not clear whether or not weaned piglets (8 – 20 kg) are included in the category of sows with litters. The category 'sows' is not clearly explained in the documents.

Regarding poultry, no categories for breeding and rearing hens are mentioned.

Currently, no information is available regarding phosphate excretion from livestock in Poland.

12 Spain

12.1 Methodology

Spain has standards of N production per animal, that are updated periodically (last updated in 2010 for Catalonia), based on measurements and theory. Depending on the type of feeding, declared by the farmers, the annual N production is accepted to be decreased by a percentage. This percentage is legally defined (6%, 12% reduction of N excretion), and based on scientific measurements. The standards for Spanish manure excretion are explained in a report of the Danish Environmental Protection Agency (2013)

12.2 Animal categories

12.3 Data origin

12.3.1 Grazing animals

Table 12.1 Nitrogen excretion values of grazing animals per animal place per year (Spanish Ministerio de Agricultura, 2010)

Animal species	*Category*	Production kg N/place/y
Cattle	Cattle <12 month	18.07
	Cattle 12 - 24 month	27.94
	Dairy cattle	86.65
	Suckler cow	52.46
Sheep	Lambs <3 month	2.09
	Sheep 3 - 12 month	3.25
	Breeding ewe > 12 month	5.49
Goat	Goat <3 month	2.40
	Goat 3 - 12 month	4.75
	Breeding goat > 12 month	8.18
Horse	Colt < 24 month	19.5
Horse	Adult horse	45.9

No data regarding phosphorus excretion in Spain is available.

12.3.2 Pigs

Table 12.2 provides the different pig categories that are distinguished in Spain. N and P contents per kg of live weight are not available yet.

Table 12.2 The N and P contents (g/kg live weight) in different categories of pigs in Spain

Category	Estimated weight (kg)	Age/ Physiological state	N-content of live weight (g/kg)	P-content (g/kg)
Weaned piglet	6 - 20	1 -2 month	?	?
Growing – finishing pig	20 - 100	2 – 6 month	?	?
Growing – finishing pig	20 – 125	2 - > 6.5 month	?	?
Gestating sow			?	?
Adult sow			?	?

Rearing sow to first mating		3.5 – 6.5 month	?	?
Boar		3.5 – 12 month	?	?
Boar		> 12 month	?	?
Sow with piglets up to 6 kg			?	?
Sow with piglets up to 25 kg			?	?
Sow including piglets and growing – finishing pigs			?	?

The N contents of the different categories of pig diets in Spain are provided in Table 12.3. The P contents of the different diets are not available yet.

Table 12.3 N and P contents (g/kg) in different categories of Spanish pig diets

Category	N-content	P-content
Diet weaned pigs (6-20 kg)	32.9	?
Growing – finishing pig diet (20-49 kg)	30.9	?
Growing – finishing pig diet (50-79 kg)	28.4	?
Growing – finishing pig diet (80-109 kg)	26.7	?
Growing – finishing pig diet (> 109 kg)	23.1	?
Boar Diet (3.5 - 12 month)	28.4	?
Boar Diet (> 12 month)	26.7	
Rearing sow to first mating (3.5 – 6.5 month)	28.4	?
Sow first parity (6.5 – 11 month)	26.0	?
Lactation and gestation (> 12 month)	26.0	?
Lactating and gestation high performance (> 12 month)	30.2	?

Table 12.4 provides the N excretion values for the different pig categories in Spain.

Table 12.4 Nitrogen excretion values of pigs per animal place per year (Spanish Ministerio de Agricultura, 2010)

Category	Production (kg N/place/y)
Piglets 6 - 20 kg	1.71
Growing – finishing pigs 20 - 100 kg	6.83
Growing – finishing pigs 20 - 125 kg	7.69
Gestating sow	18.79
Adult sow	22.70
Breeding sow to first mating	11.47
Boar	15.18
Sow with piglets up to 6 kg	20.44
Sow with piglets up to 20 kg	26.22
Sows including piglets and growing – finishing pigs	73.19

No data regarding phosphorus excretion in Spain is available yet.

12.3.3 Poultry

Table 12.5 provides the different poultry categories that are distinguished in Spain. N and P contents per kg of live weight are not available yet.

Table 12.5 The N and P contents (g/kg live weight) in different categories of poultry in Spain

Category	Estimated Weight (kg)	Age/ Physiological state	N-content of live weight (g/kg)	P-content (g/kg)
Rearing hens white (industrial)		0 – 17 wk	?	?
Rearing hens brown (industrial)		0 - 18 wk	?	?
Free range laying hens white (industrial)		17 – 70 wk	?	?
Free range laying hens brown (industrial)		18 – 70 wk	?	?
Rearing hens (small scale)		0 – 18 wk	?	?
Free range laying hens (small scale)		18 – 70 wk	?	?
Broilers				

The N contents of the different categories of pig diets in Spain are provided in Table 12.6. The P contents of the different diets are not available yet.

Table 12.6 N and P contents (g/kg) in different categories of Spanish poultry diets

Category	N-content	P-content
Rearing hens white (industrial)	29.3	?
Rearing hens brown (industrial)	29.3	?
Free range laying hens white (industrial) 17 – 52 wk	29.6	?
Free range laying hens white (industrial) 52 – 70 wk	28.5	?
Free range laying hens brown (industrial) 18 – 52 wk	29.1	?
Free range laying hens brown (industrial) 52 – 70 wk	28.2	?
Rearing hens (small scale)	26.4	?
Free range laying hens (small scale) 18 – 52 wk	26.1	?
Free range laying hens (small scale) 18 – 52 wk	25.4	?
Broilers	?	

Table 12.6 provides the N excretion values for the different poultry categories in Spain.

Tabel 12.6 Nitrogen excretion values of poultry per animal place per year (Spanish Ministery of Agriculture)

Category	Production (kg N/place/y)
Industrial layers	0.42
Industrial rearing chicks < 19 month	0.14
Free range hens	0.39
Rearing hens small scale < 20 month	0.12
Broilers	0.34

No data regarding phosphorus excretion in Spain is available.

12.4 Assessment

12.4.1 Complexity of the methodology

Every year, farmers must declare the census of animals at their farms. Every farm is registered based on its maximum animal capacity. Also, there is the Spanish internet system for the traceability of animals: the RIIA registers individually every animal, and the REMO system is the register of movements or transport of animals. These are included in the Integral System of Animal Traceability (SITRAN):
http://www.magrama.gob.es/es/ganaderia/temas/trazabilidad-animal/registro/#para1

The declaration of the manure management plan (to fertilization, to plants, etc.) is submitted by farmers every year. Also, all manure movements are registered in an obligated book for every farmer. Some service companies help farmers to maintain this book updated. This is relatively easy for collective management plans. Verification is done periodically by regional authorities for a sample of farmers.

Data gathering – nitrogen balance
Manure management plans are declared and validated. The manure and mineral fertilizers applications are recorded in an official registers book. Periodical inspections are established by Decree 136/2009 in Catalonia. Inspections are based on measures of nitrates and phosphorus in soil one month after harvesting. The official registers book include mineral fertilizers.

12.4.2 Strength and weakness

The method used in Spain to calculate the N excretion on the national level is strong, because it's an accumulation of the N excretion of all individual farms. The N excretion per farm is determined by the balance between N intake and N deposition (input/output measurements), which is registered by each farmer in a well-defined method of bookkeeping. A weak point is that data regarding feed intake levels and mineral retention per category are not available and that no information is available regarding P excretion.

13 United Kingdom

13.1 Methodology

The UK Government is committed to reducing nutrient emissions from agriculture, to enable compliance with a number of EU Directives (e.g. Nitrate Directive, National Emissions Ceilings Directive, Water Framework Directive).
The UK standards for N excretion builds on the data accumulated within the European Commission (EC) study and is based on the nutrient balance approach. The calculation of N and P excretion in excreta is part of the National Ammonia Reduction Strategy Evaluation System (NARSES), using a mass-flow model described by Webb and Misselbrook (2004). This model is also used to evaluate gaseous N losses following excretion, during the housing period and during manure storage. The mass flow model allows the expression of 'N production standards' for livestock excreta as (i) ex-animal (i.e. as excreted), (ii) ex-housing and (iii) ex-storage (i.e. as at land spreading).
The ammonia emission factors (EFs) for livestock types relate the different phases of manure management. The Inventory of Ammonia Emissions from UK Agriculture (IAEUK) EFs are based entirely upon data collected from within the UK. Ammonia emissions during housing are expressed as g per livestock unit (LU) d^{-1} for each of the major livestock classes. In this context, a LU is taken as equivalent to a 500 kg dairy cow. Estimates of ammonia emissions from "typical" housing and management systems, for the major livestock types, are shown in Tables 13.1.

Table 13.1 Estimates of N and TAN % emitted as ammonia from livestock buildings (from Webb and Misselbrook, 2004)

Livestock	Manure/Housing	Ammonia emissions as % N	TAN[1]
All cattle)	Slurry	18.5	31.0
Except calves)	FYM	12.5	21.0
Calves	FYM	3.5	6.0
Sheep	FYM	13.5	22.5
All pigs except weaners	Slurry	18.0	25.5
Weaners	Slurry	10.5	15.0
Sows and boars	FYM	16.5	23.5
Fatteners and weaners	FYM	24.0	34.0
Laying Hens	Manure	29.5	37.0
Pullets	Manure	19.5	24.5
	Litter	21.0	26.5
Breeders	Manure	19.5	24.5
	Litter	21.0	26.5
Broilers and turkeys	Litter	21.0	26.5

[1] Total ammoniacal nitrogen (TAN)

13.2 Animal categories

Several categories of animals are distinguished:

Grazing animals

Cattle :
Dairy cow, Suckler cow , Cattle (0-1 year old), Cattle (1-2 years old), Cattle > 2 years

Small ruminants:
Mountain ewe & lambs, Lowland ewe & lambs , Mountain hogget, Lowland hogget , Goat

Other grazing animals:
Horse (>3 years old), Horse (2-3 years old), Horse (1-2 years old), Horse foal (< 1 year old), Donkey/small pony, Deer (red) 6 months 2 years, Deer (red) > 2 years, Deer (fallow) 6 months -2 years, Deer (fallow) > 2 years, Deer (sika) 6 months — 2 years, Deer (sika) > 2 years

Monogastrics

Pigs:
Breeding unit (per sow place), Integrated unit (per sow place), Finishing unit (per pig place)

Poultry:
Laying hen per bird place, Broiler per bird place, Turkey per bird place

13.3 Data origin

13.3.1 Grazing animals

13.3.1.1 Dairy cows

Although a number of factors influence the amount of N excreted by dairy cows, the one having the greatest effect is N intake, which is a function of the amount of feed consumed and its N content.
Using the mass balance approach, N excretion of a 600 kg live weight dairy cow with high and average annual milk yields of >9000 and 6973 kg/lactation[3], respectively are summarised below. For comparison, N excretion by a small breed of cow (e.g. Jersey or Guernsey breed) is also estimated.

Table 13.2. Calculation of manure N excretion from dairy cows at different levels of milk production using the Ketelaars and van der Meer (2000) balance model and UK production data

Parameter	Units	High (>9000)	Medium	Small breeds
Milk yield	kg FCM	9000	6973	4500
Adult cow live weight	kg	600	600	500
Total feed intake	kg DM	6803	5,790	4,259
Diet N content	g/kg DM	26.5	26.5	26.5
Total N intake	kg/cow/year	180	153	113
N retention in milk	kg/cow/year	45.0	35.0	22.5
N retention in calf	kg	0.65	0.65	0.65
N retention in live weight gain	kg	0.63	0.63	0.63
Total N retained	kg/year	46.3	36.3	23.8
N excreted	kg/year	133.7	116.7	89.2

13.3.1.2 Calves

Typical values for feed and N intakes for an 8-week weaned calf are shown in Table 13.3. The annual N output per 'calf place' assumes a 7-day empty period between calves, but this figure will have relevance on specialist calf rearing units only, where calf pens are occupied for much

[3] Average milk yield/cow in the United Kingdom, 2003 (*Source: MDC Dairy Facts and Figures, 2004)*

of the year. In other circumstances, where heifer calves are kept as replacements for milking cows, the N excretion per individual calf is the relevant figure to be considered in the manure nutrient inventory for the farm.

Table 13.3. Calculation of manure N excretion based on typical feed and N intakes for a dairy calf weaned at 8 weeks.

Parameter	Units	Values
Birth weight	Kg	40
Weaning weight	Kg	65
Feeding period	Days	56
N content of gain	g/kg	27.5
N retained	kg/calf	0.7
Mean milk powder consumed	kg/day	0.5
Mean dry coarse feed consumed	kg/day	0.6
N content of milk powder	g/kg	35.2
N content of coarse mix	g/kg	27.0
N intake	kg/calf	2.3
N excretion	kg/calf	1.6
N excretion	kg/calf place/year	9.3

13.3.1.3 Suckler cows

Suckler cows differ from dairy cows in that the calf typically remains with the mother for up to six or seven months before being weaned. It is possible to calculate, by mass balance, the N excretion by different sizes of suckler cow.

Table 13.4. Production data and manure N outputs for suckler cows with calf.

	Small breed	Large breed
Adult cow weight, kg	450	600
DMI (kg DM/year)	2956	3942
N intake, kg/year	76	100
LW gain of cow, kg	30	30
N in gain cow, kg/year*	0.8	0.8
Calf weaning weight, kg	180	250
N in calf, kg/year*	7.3	7.3
N in animal products	8.0	8.0
N excretion, kg/year	68	92

* ERM (1999) reference values

13.3.1.4 Growing cattle

Available data illustrate the differences that can occur in N excretion between production systems, particularly as a result of differences in diet N content.

Table13. 5. Estimated manure N excretion by growing cattle on different production systems.

Parameter	Units	Grass silage-based diets	Cereal beef production
Initial weight	Kg	49	90
Final weight	Kg	552	440
Feeding period	Days	456	270
Feed consumed	kg DM	3484	1667
Feed N	g/kg DM	24	22.4
Feed N consumed	kg/animal	83.6	37.3
Liveweight gain	Kg	503	348
N content of live weight gain	g/kg	27	27
N in live weight gain	Kg	13.6	9.4
N excretion	kg/animal	70	28
N excretion	kg/animal place/year	56	38

The ERM (1999) report, on which the European Communities (2002) was based, recognised the importance of breed type, age (or size) and dietary N content, on N excretion.

Table 13.6. Nitrogen Production Standards (kg N/animal/year) proposed for growing cattle of small and large breeds with different age intervals; averages for male and female animals (ERM, 1999).

Growing cattle	Small breed			Large breed		
	Age (years)			Age (years)		
	0-1	1-2	2-3	0-1	1-2	2-3
% N in diet						
Low (2.0%)*	18	31	35	24	41	47
Medium (2.7%)	24	43	48	32	57	64
High (3.4%)	30	55	61	40	74	81

* 2.3% for animals of 0-1 year old.

13.3.1.5 Grower/fatteners older than 24 months

The majority of cattle reared for meat reach maturity within 18 months of age. Relatively few beef cattle reared for meat are kept beyond 24 months of age. For those that are, rates of live weight gain and protein deposition are generally low, while protein (N) intakes are usually well in excess of requirements. Nitrogen excretion per animal per day is therefore relatively high. Furthermore, these cattle are unlikely to be retained for a year, and therefore any estimate of N excretion on a farm will need to take account of the length of time that they are on the farm. Many factors will influence the amount of N excreted by these animals but, as an approximate estimate, a value of 152 g/animal/day is proposed (i.e. 56 kg N/animal place/year).

13.3.1.6 Bull beef

A common practice is to feed a high protein concentrate at a fixed rate (kg/head/day) during the entire life of the animal, with forage fed to appetite; as animals grow and forage intake increases, so the protein content of the diet declines, matching the reduced need for protein as the animal matures. Based on typical feed and production data, N excretion has been estimated for Holstein bulls on cereal and silage (grass and maize)-based diets (Table 13.7).

Table 13.7. Feed and production data, with estimated N balance for (Holstein) bulls.

Parameter	Units	Cereal beef	Maize silage	Grass silage beef
Weaning weight	kg	90	90	90
Age at slaughter	months	13	15	16
Slaughter weight	kg	480	490	500
LWG, weaning to slaughter	kg/day	1.35	1.1	1
Feed consumed				
Concentrate	kg/animal	1872	510	1040
Maize silage	kg DM/animal	-	1920	1500
Nitrogen intake	kg	35.9	65.3	61.5
N in gain	g	5118	5610	5746
Total N excretion	kg/animal	30.8	59.7	55.8
Total N excretion*	kg/animal place/yr	38.9	59.9	49.7

** Note. Annual excretion based on 289, 364 and 410 days growth periods, respectively, for these production systems*

13.3.1.7 Dairy heifer replacements

The N content of the diet of replacement heifers will vary according to age and season. Many heifers will predominantly be at pasture during the summer months, where the N content of grass can vary from 22 to 35 g N/kg DM. In winter months, dairy heifer replacements are usually fed conserved forages plus concentrate feeds, in which dietary N contents tend to be nearer 26 g/kg DM. Average values of 27 and 26 g N/kg DM for diets in the first and second years, respectively, have been used in the calculations in Table 13.8.

Table 13.8. Estimated N excretion by replacement dairy heifers.

Parameter	units	2-12 months	12-24 months
Initial weight	kg	49	310
Final weight	kg	310	580
Feeding period	days	304	365
Feed consumed	kg DM/day (mean)	4.2	7.5
Feed N	g/kg DM	27	26
Feed N consumed	kg/animal	34.5	73.9
Liveweight gain	kg	261	270
Empty bodyweight gain	kg	156.6	162
N content of live weight gain	g/kg	28	28
N in live weight gain	kg	4.4	3.9
N excretion*	kg/animal	30.1	67.2

** Note. Estimate for young heifer on animal place/yr may include N excretion for the 0-2 month period of the calf, i.e. 1.6 kg/calf (Table 2).*

13.3.1.8 Proposed N output standards cattle

Table 13.9. Manure N output standards for cattle, with allowances for gaseous N losses from housing and manure storage

Stock	Class	LW kg	Excreta Daily kg or l	Occup. % year	Previous Standards $kg.yr^{-1}$	Annual N output & source: Proposed $kg.yr^{-1}$	Other $kg.yr^{-1}$	ERM $kg.yr^{-1}$	N production standards after calculated N losses: ex-house	ex-store
Dairy cow	High yield	600	64	100	-	133.7	-	-	116.9 (13%)	115.1 (14%)
Dairy cow	Ave yield	600	53	100	116	117.0	91	115	102.3 (13%)	100.7 (14%)
Dairy cow	Small	500	42	100	96	89.0	85	82	77.8 (13%)	76.6 (14%)
Dairy heifer replacemet	2-12 mths	50-310	*20*	100	-	32.0			29.3 (8%)	29.1 (9%)
Dairy heifer replacement	13-24 mths	310-580	*40*	100	-	67.0			61.3 (8%)	60.9 (9%)
Beef suckler	Large	600	*45*	100	58	92.0	54	94	83.6 (9%)	83.0 (10%)
Beef suckler	Small	450	32	100	-	68.0		63	61.9 (9%)	61.2 (10%)
Grower	>2 years		32	100	58	56.0	54	64	50.9 (9%)	50.5 (10%)
Grower	18 mths	520	26	100	47	56.0		57	50.9 (9%)	50.5 (10%)
Grower place	12 mths	270	*20*	100	-	38.0	46		34.6 (9%)	34.3 (10%)
Grower	3 - 12 mths			83	-	31.6			28.8 (9%)	28.4 (10%)
Bull beef	3– 15mths	490	*26*	100	-	60.0			54.6 (9%)	54.1 (10%)
Br. Bulls	<2 years	550	*26*	100	-	56.0			50.9 (9%)	50.5 (10%)
Br. Bulls	Adult	650	*26*	100	-	53.0			48.2 (9%)	47.8 (10%)
Calf place	2 months	65	7	89	7	9.3	-	-	8.9 (5%)	7.9 (15%)
Calf	Per animal			15		1.6	-	-	1.5 (5%)	1.4 (15%)

Note: Above estimates based on slurry management system.

13.3.1.9 Ewes plus lambs

As with other livestock, the factor that has the greatest effect on N excretion per ewe is the N content of the diet, with increasing N intake resulting in an increase in N excretion.

Table 13.10. Production data and N outputs for 75 kg live weight lowland ewes with offspring

Parameter	Units	Production data	N balance (kg/ewe/year)
Live lamb production	no./ewe/year	1.2	
Slaughter weight lambs	kg	38	
Total N intake	kg/ewe/year		13.4
Annual weight change ewe	kg	+4	
Wool production	kg/ewe/year	3	
N content of lambs	g/kg	13.0	0.59
N content of ewe live weight gain	g/kg	9	0.04
N content of wool	g/kg	165	0.50
Total N retention	kg/ewe/year		1.13
N excretion	kg/ewe/year		12.3

13.3.1.10 Store lambs

Weaned lambs that have not been finished by the beginning of October are generally termed 'store lambs'. Depending on the type of lamb and feedstuff available, the stores are finished on short- or long-term keep. Estimates of N excretion for store lambs are given in Table 13.11.

Table 13.11. Production data and N outputs for store lambs

Parameter	Units	Short keep	Long keep
Liveweight at start	kg	35	35
Liveweight at slaughter	kg	50	60
N content of gain	g/kg	27.2	27.2
N retention	kg	0.41	0.68
Feeding period	days	56	150
DM intake	kg/d	0.7	0.5
N content of diet	g/kg	23	17
N intake	kg/lamb	0.90	1.28
N excretion	kg/lamb	0.49	0.60

13.3.1.11 Goats

As for dairy cows, rations for dairy goats consist of forages and concentrates, although during non-lactating periods only forages are fed. In the absence of any other data, values for the N content of feed and live weight gain proposed by Ketelaars and van der Meer (2000) have been used.

Table 13.12. Estimates of annual N intake and excretion by milking goats.

Parameter (units)	
Live kid production (per female)	1.8
Adult female weight (kg)	65
Weaning weight of kids (kg)	7.0
Nitrogen intake	
Feed intake (% of live weight)	3.50
Feed intake (kg/female)	830
N content of feed (g/kg)	29.0
N intake (kg/female)	24.1
Nitrogen retention	
Liveweight gain female (kg)	2
Liveweight production kids (kg/female)	13
N content live weight females (g/kg)	24
N content kids (g/kg)	35
Milk production (kg/female)	600
N content milk (g/kg)	5.0
N retention in female gain (kg)	0.05
N retention kids (kg/female)	0.44
N retention milk (kg/female)	3.0
Total N retention (kg/female)	3.5
N excretion (kg/female)	**20.6**

13.3.1.12 Horses

The amount of feed consumed by the healthy animal is influenced by many factors, but is principally determined by the energy needs of the horse, to support maintenance, activity, pregnancy, lactation etc. Intake may then be modified by the quality of the feed available and the ability of the gastrointestinal tract to hold that amount of feed. Most horses are fed dry matter intakes near to 2.5% of live weight (Hanson et al., 1996). The results of a survey of typical horse feeding practices in the UK, undertaken in the 1990's, are given in Table 13.13.

Table 13.13. A guide to the amounts of forage and concentrates fed (in dry matter as % of live weight) in the UK according to a number of nutritionists

Type of Animal	% of Body weight on an as fed basis ***Figures in bold italic refer to ratios of feed***		
	Forage	Concentrates	Total
Mature horse at maintenance	2 1.5-1.8 1.5-2 ***95***	0 0.2- 0.5 0 - 0.5 ***5***	2 2 1.75 - 2
Mares late gestation	1.2 1.4-1.8 1.5-2.0 ***non-TB* 80*** ***TB 40***	0.8 0.2-0.6 0.25-0.75 ***non-TB 20*** ***TB 60***	2 2 2-2.25
Mares early lactation	1.5 1.5 1.5 –1.75 ***non-TB 80*** ***TB 40***	1 1.5 1-1.5 ***non-TB 20*** ***TB 60***	2.5 3 2.5-3
Mares late lactation	1.4 1.5-1.75 1.25 –1.75 ***non-TB 90*** ***TB 50***	0.6 0.75-1.0 0.75-1.25 ***non-TB 10*** ***TB 50***	2 2-2.5 2-2.5
Light work	1.4 1.5-1.8 1.5-2.0 ***90***	0.6 0.2-0.6 0.1-0.75 ***10***	2 2 1.75- 2.25
Moderate work	1.5 1 1-1.5 ***80***	1 1 0.5-1.0 ***20***	2.5 2 2-2.5
Intense work	1.25 1-1.25 0.75-1.5 ***50***	1.25 1.25-1.5 1.25-1.5 ***50***	2.5 2.5 2-2.75
Dressage	- 1-1.5	- 0.5-1	2.5 2
Racing – flat	0.6 1-1.25 ***40***	1.4 - 1.9 1.25 –1.5 ***60***	2-2.5 2-2.5
Racing National Hunt	0.6 1.25 ***50***	1.4 - 1.9 1.25 ***50***	2.5 2-2.5
Show jumping	1.5 –1.75 1.2 ***80***	0.75 – 1 0.8 ***20***	2.5 2
Eventing	1.5 1.25-1.5 ***70***	1 1-1.25 ***30***	2.5 2-2.5
Hunting	1.5 –1.75 1-1.2 ***50***	0.75-1.0 0.8-1 ***50***	2.5 2
Weanling foal 6 months : TB	0.75 ***40***	1.75 ***60***	2.5

* Thoroughbred

Table 13.13 continued….	% of Body weight on an as fed basis		
	Forage	Concentrates	Total
Weanling foal 6 months : Non-TB	1 ***50***	1.5 ***50***	2-2.5
Yearling foal 12 months : TB	1.2 1-1.2 ***50***	0.8 0.8-1.0 ***50***	2 2
Yearling foal 12 months : non –TB	1.2 1-1.2 1.25-1.5 ***70***	0.8 0.8-1.0 0.5-1.0 ***30***	2 2 2-2.25
Long Yearling: TB	1.2 1.25 –1.5 ***50***	0.8 1-1.25 ***50***	2 2-2.5
Long Yearling: Non- TB	1.2 1.4 ***70***	0.8 0.6 ***30***	2 2
Two year old : TB	1.4 1.4 1.0-2.0 ***40 Racing***	0.6 0.6 0.5-1.0 ***60***	2 2 2-2.5
Two year old : non TB	1.4 1.5 1.25-1.75 ***80***	0.6 0.5 0.5-0.75 ***20***	2 2 2-2.25

13.3.1.13 Deer

Deer are ruminants and their diets consist predominantly of forage therefore, although for farmed deer some concentrate feeds may be given They exhibit seasonal changes in patterns of digestion. There is little evidence of differences between deer and sheep in most aspects of nitrogen (N) digestion and metabolism and, consequently, at the same N intakes the two species have not been found to differ in apparent N digestibility or the amount of N excreted in the urine. The nutritional requirements of adult hinds are presented in Table 13.14.

Table 13.14. Dry matter and N intakes of adult hinds (95 kg live weight)

	Days	Dry Matter Intake (kg/day)	Crude Protein (% DM)	N intake (kg)
Non-pregnant	60	1.7	10	1.6
Early to mid pregnancy	150	2.0	10	4.8
Late pregnancy	80	2.3	14	4.1
Lactation	75	3.0	17	6.1
Total	365			16.7

Source: Adam (1994)

13.3.1.14 Young deer

Typical feed and N intakes of deer calves from weaning at 3-4 months of age up to 15-16 month of age are summarised in Table 13.15.

Table 13.15. Feed and N intake by weaned red deer calves (based on Adam, 1994)

	Days	Live weight gain (g/day)	DMI (kg/day)	Crude protein (%)	N intake (kg)
3-6 months (Sept-Dec)	90	140-200	1.0-1.5	16-17	3.0
6-8 months (Dec-Feb)	60	0-40	1.0-1.3	10	1.0
8-11 months (Feb-May)	90	90-270	1.3-2.2	12-17	4.3
11-16 months (May-Oct)	150	100-200	1.5-2.5	14	6.7
Total	390				15.0

13.3.1.15 Proposed N output standards other (than cattle) categories grazing animals

Table 13.16. Manure N output standards for sheep, goats, deer and horses, with allowances for gaseous N losses before landspreading

Stock	Class	LW	Excreta	Occup.	Previous	Annual N output & source			N production standards after calculated N losses	
			Daily		Standards	Proposed	Other	ERM		
		kg	kg or l	% year	$kg.yr^{-1}$	$kg.yr^{-1}$	$kg.yr^{-1}$	$kg.yr^{-1}$	ex-house	ex-store
Sheep										
Adult ewes (FYM)						-			-	-
Hill ewe + lamb	lamb 30-35kg	40-55kg	*3.3 (3.8)*	100	-	7.6			7.6 (-)	7.6 (-)
Lowland ewe+ lamb[3]	lamb 35-40kg	60-80kg	*5.0 (5.8)*	100	9	12.3		12.9	12.1 (2%)	11.9 (3%)
Lambs – FYM	Short stores	35 – 50	*1.8 (2.1)*	16		0.49		-	-	0.49 (-)
Lambs – FYM	Long stores	35 – 60	*1.8 (2.1)*	41	1.2	0.60		-	-	0.60 (-)
Goat										
Milking goats	Housed	65	*3.5 (4.0)*	100	-	20.6	9.0	16.5	17.9 (13%)	15.0 (27%)
Deer										
Breeding hinds		95	*5.0 (5.8)*	100		16.2			15.7 (3%)	15.2 (6%)
Calves - finishers		45-100kg	*3.5 (4.0)*	100		13.4			12.7 (5%)	12.0 (10%)
Horse										
Adult horse	2-3 years	400	24.5	100	-	23.1	44.0	39.0	22.2 (4%)	21.0 (9%)
	> 3years	600					50.0	53.0		

Notes:-

13.3.2 Pigs

13.3.2.1 Sows and piglets

In a typical commercial pig unit, sows and piglets remain with their mothers for 3-4 weeks until they are approximately 7 kg live weight, when they are weaned. Estimates of feed intake and composition are required separately for dry and lactating sows. It is assumed that the piglets consume only sows' milk. The minerals (N/P) in output consists of the minerals in the piglets and the minerals in the live weight of the sows. To estimate the minerals retained in sows, a typical annual replacement rate (40%) has been used. UK industry standards for sows are used in Table 13.17, to estimate annual mineral excretion.

Table 13.17. Production data and N outputs for sows and piglets

Parameter	
Weaning weight piglets (kg)	7
Piglets weaned (per sow per year)	23
Feed intake sow (kg)	
• Dry sow	710
• Lactating sow + weaning ration	439
N content of sow feed (g/kg)	
• Dry sow	20.0
• Lactating sow + weaning ration	27.2
N intake sow (kg/sow/year)	**26.1**
Nitrogen retention	
Live weight production of piglets (kg)	161
N content of live weight gain - sow (g/kg)	25.6
N content of live weight gain - piglet (g/kg)	30.4
N retention sow (kg/year)	1.10
N retention piglets (kg/year)	4.89
Total N retention (kg/year)	5.99
Nitrogen excretion (kg/sow)	**20.1**

13.3.2.2 Growing finishing and fattening pigs

This category refers to pigs reared for slaughter, from weaning to slaughter. From weaning to slaughter takes approximately 140 days which, together with a 7 day period between batches for cleaning of the accommodation and restocking might allow 2.48 production cycles per year. (however, see footnote to Table 13.15, which details typical production data). Table 13.18 provides the N and P contents in different categories of pigs (Cottrill and Smith, 2010; Cottrill et al., 2010)

Table 13.18 The N and P contents (g/kg live weight) in different categories of pigs (Cottrill and Smith, 2010; Cottrill et al., 2010)

Category	Estimated weight (kg)	Age/ Physiological state	N-content of live weight (g/kg)	P-content (g/kg)
Weaned piglet 1	7.0	3 – 4 weeks	30.4	5.0
Weaned piglet 2	12.0		25.0	5.0
Growing pig	30.0		25.0	5.0
Finishing pig	65.0		25.0	5.0
Rearing sow	90 – 130	19 – 29 weeks	22.0	?
Breeding sow		Dry + lactating	25.6	?
Sow at slaughter	250	1 wk after weaning	25.6	?
Boar	250		27.4	?

The N and P contents of the different categories of pig diets in the UK are provided in Table 13.19.

Table 13.19 N and P contents (g/kg) in different categories of pig diets (Cottrill and Smith, 2010; Cottrill et al., 2010)

Category	N-content	P-content without phytase	P-content with phytase
Starter diet weanling pigs (7-12 kg)	35.2	6.8	5.8
Grower diet weanling pigs (12-30 kg)	32.0	6.5	5.5
Starter diet growing finishing pigs (30-65 kg)	29.6	6.0	5.0
Finisher diet growing finishing pigs (65-100 kg)	27.2	5.7	4.6
Rearing sow diet (90 – 130 kg)	25.6	6.5	5.5
Lactating sow diet + weaning ration	27.2	6.8	5.8
Gestating sow diet	20.0	6.5	5.5
Boar Diet	24.8	?	?

Table 13.20 provides the N and P balance for the different pig categories in the UK.

Table 13.20 N and P balance for the different pig categories on a year base (Cottrill and Smith, 2010; Cottrill et al., 2010).

Category	Feed intake (kg)	N intake Cumulative live weight (kg)	P intake -/- phytase (kg)	P intake +/+ phytase (kg)	N deposition (kg)	P deposition (kg)	N excretion (kg)	P excretion -/- phytase (kg)[1]	P excretion +/+ phytase (kg)[1]
Sow incl. piglets (7 wk of age)	1149	26.10	8.21	6.91	5.99	1.08	20.1	7.13 (16.33)	5.83 (13.35)
Breeding sow (90 – 130 kg)	770	19.73	5.01	4.11	4.23	1.51	15.5	3.50 (8.02)	2.60 (5.95)
Piglets phase 1 (7 – 12 kg)	92	3.21	0.62	0.53	1.91	0.38	1.30	0.24 (0.55)	0.15 (0.34)
Piglets phase 2 (12 – 30 kg)	292	9.31	1.96	1.66	4.11	0.87	5.20	1.09 (2.50)	0.79 (1.81)
Grower phase (30 – 65 kg)	570	16.90	3.42	2.86	5.90	1.18	11.00	2.24 (5.13)	1.68 (3.85)
Finisher phase (65 – 100 kg)	778	21.23	4.54	3.75	6.22	1.29	15.01	3.25 (7.44)	2.46 (5.63)
Growing–finishing pig (25 – 100 kg)	576	16.68	3.45	2.87	5.76	1.16	10.9	2.29 (5.24)	1.71 (3.92)
Boar (250 kg)	1095	27.16	?	?	2.00	?	25.16	5.2 (11.91)	4.4 (10.08)

[1]) Phosphate excretion between brackets.

13.3.2.3 Proposed N output standards for pigs

Table 13.21. Manure N output standards for pigs, with allowances for gaseous N losses before landspreading

Stock	Class		Excreta		Previous standards	Nitrogen output & source				N production standards after calculated N losses	
	Age	LW	Daily	Occup.		Proposed		Other	ERM		
	Range/Ave.	kg	kg or l	% year	N $kg.yr^{-1}$	$kg.pig^{-1}$	$kg.yr^{-1}$	N$kg.yr^{-1}$	N $kg.yr^{-1}$	ex-house	ex-store
1 sow place, inc litters[5]		220	10.9	100	19.5	22.8	22.8	35.0	21.5	19.7 (13%)	18.0 (21%)
1 sow place, inc litters[5]		220	10.9	100	-	20.1	20.1			17.5 (13%)	16.0 (21%)
Maiden gilt – FYM		90-130	5.6 (6.4)	90	13.0	3.22	15.5			12.8 (18%)	11.1 (29%)
Boar – FYM		250	8.7 (10.0)	100			25.0			20.6 (18%)	17.5 (30%)
Weaner 1	23-40 days	7-12	1.3 (2.2)	71	3.0	0.09	1.3			1.2 (10%)	1.0 (18%)
Weaner 2	40-73 days	12-30	2.0 (3.6)	82	6.1	0.57	5.2			4.7 (10%)	4.2 (18%)
Grower	73-120 days	30-65	3.7 (7.1)	88	9.4	1.64	11.0			8.4 (23%)	7.7 (30%)
Finisher	120-164 days	65-100	5.1 (10.0)[13]	86		2.12	15.0			11.5 (23%)	10.6 (30%)
Weaner – Finisher	23-164 days	7-100	3.5	95	10.5		10.9	9.2	10.1	8.4 (23%)	7.7 (30%)

Notes:-

13.3.3 Poultry

For rearing pullets, a total of 2.9 cycles per year is possible, based on a 16 week cycle and 2 weeks downtime for removal, cleaning and restocking.
Laying hens arrive at the layer farm at 17 wk of age and continue laying until end of lay, typically at 72 weeks of age. A two phase feeding program is followed. During the first 28 weeks, a slightly higher (17% CP) protein diet is fed, compared to a 16% CP diet during in weeks 46 – 72.
For broilers, a total of 7.4 cycles per year is realized, based on a 42 d cycle and 1 week downtime for removal, cleaning and restocking.

Table 13.22 provides the N and P contents in different categories of poultry (Cottrill and Smith, 2010; Cottrill et al., 2010).

Table 13.22 N and P contents (g/kg live weight) in different categories of poultry (Cottrill and Smith, 2010; Cottrill et al., 2010)

Category	Weight (g)	Age/ Physiological state	N-content (g/kg)	P-content (g/kg)
Egg broiler breeder	65	-	18.8	1.8
Broiler breeder pullet	42 - 2300	< 25 weeks	30.0	4.6
Broiler	0 – 2150	Slaughter	30.0	4.6
Broiler breeder hen	2300 - 3500	≥25 weeks	29.1 – 30.4	4.6
Egg laying hen	63.5 – 65.5	-	18.5	1.8
Rearing hens	35 – 1350	0 – 16 weeks	35.0	5.5
Laying hen	1350 - 2005	≥17 weeks	28.0	5.5

The N and P contents of the different categories of poultry diets are provided in Table 13.23.

Table 13.23 N and P contents (g/kg diet) in different categories of poultry (Cottrill and Smith, 2010; Cottrill et al., 2010)

Category	N-content diet	P-content -/- phytase	P-content +/+ phytase
Laying hen diet phase 1	27.2	6.0	5.0
Laying hen diet phase 2	25.6	5.5	4.5
Rearing hen diet phase 1 (0 – 3 weeks)	33.6	7.5	6.5
Rearing hen diet phase 2 (4 – 8 weeks)	30.4	7.5	6.5
Rearing hen diet phase 3 (9 – 16 weeks)	24.8	7.5	6.5
Broiler breeder pullet diet (0 – 6 weeks)	30.4	4.5	4.5
Broiler breeder pullet diet (7 – 18 weeks)	24.0	4.5	4.5
Broiler breeder pullet diet (19 – 24 weeks)	25.6	4.5	4.5
Broiler breeder diet	24.0	4.4	4.4
Broiler diet phase 1 (0 – 10 d)	36.0	7.6	6.4
Broiler diet phase 2 (11 – 23 d)	34.4	7.1	6.1
Broiler diet phase 3 (24 – 32 d)	30.4	6.8	5.8
Broiler diet phase 4 (33 – 42 d)	30.4	6.8	5.8

Table 13.24 provides the N and P balance for the different poultry categories.

Table 13.24 N and P balance for the different poultry categories on a year base (Cottrill and Smith, 2010; Cottrill et al., 2010)}

Category	Feed intake (kg)	N intake (kg)	P intake -/- phytase (kg)	P intake +/+ phytase (kg)	N deposition (kg)	P deposition (kg)	N excretion (kg)	P excretion -/- phytase (kg)[1]	P excretion +/+ phytase (kg)[1]
Male and female rearing hens (<18 weeks)	16.2	0.432	0.122	0.106	0.136	0.037	0.296	0.085 (0.195)	0.069 (0.158)
Laying hens (cages) (≥ 18 weeks)	40.1	1.060	0.234	0.193	0.340	0.035	0.720	0.199 (0.456)	0.158 (0.362)
Laying hens (free range) (≥ 18 weeks)	42.6	1.159	0.248	0.205	0.330	0.033	0.830	0.215 (0.492)	0.172 (0.394)
Broiler breeder pullets (< 25 weeks)[2]	22.0	0.566	0.158	0.137	0.142	0.022	0.424	0.136 (0.311)	0.115 (0.263)
Male and female Broiler breeders (≥ 25 weeks)	55.4	1.331	0.317	0.260	0.308	0.032	1.022	0.285 (0.652)	0.228 (0.522)
Broilers	28.5	0.906	0.198	0.170	0.477	0.073	0.429	0.125 (0.286)	0.097 (0.222)

[1]) Phosphate excretion between brackets.
[2]) Assuming 2 cycles per year.

13.3.3.1 Proposed N output standards for poultry

Table 13.25. Manure N output standards for poultry, with allowances for gaseous N losses before land spreading

Stock[1]	Age Range/Ave	LW kg	Excreta Daily kg or l	Occup. % year	Previous Standards $kg.yr^{-1}$	Annual N output & source: Proposed $kg.yr^{-1}$	Other $kg.yr^{-1}$	AB-DLO $kg.yr^{-1}$	N production standards after calculated N losses: ex-house	ex-store
Laying hens – cages	392 days	1.95	0.115	97	0.66	0.72	0.56	0.79	0.45 (38%)	0.40 (45%)
Laying hens – free range	392 days	2.05	0.115	97	-	0.83			0.58 (30%)	0.53 (36%)
Broiler places	40 days	2.15	0.06	85	0.495	0.43	0.24	0.51	0.37 (13%)	0.33 (23%)
Broiler pullets	24 weeks	2.4	*0.04*	92	-	0.42	-	-	0.32 (23%)	0.29 (31%)
Broiler breeders	36 weeks	2.4 –3.5	*0.115*	95	-	1.02	-	-	0.78 (23%)	0.7 (31%)
Replacement layer pullets	16 weeks	1.35	*0.04*	89	0.125	0.30	-	-	0.23 (23%)	0.21 (31%)
Turkeys (male)	20 weeks	12.6	0.16	91	1.39	1.80	1.0	1.93	1.36 (24%)	1.23 (32%)
Turkeys (female)	16 weeks	6.1	*0.12*	88	0.65	1.34	-	-	1.02 (24%)	0.91 (32%)
Ducks	49 days	3.3	*0.1*	83	0.9	1.33	-	1.21	1.02 (23%)	0.75 (44%)
Ostriches	14 months	110	*1.6*	100	-	1.4	-	-	1.4 ( )	1.4 ( )

Notes:-

13.4 Assessment

13.4.1 Complexity of the methodology

Standards for manure N output by farm livestock, based on the nutrient balance approach have been assembled for all the major livestock categories. However, due the large number of animal categories this system becomes complex. Even more when updating leads to different animal categories or to significantly different standards.

For suckler cows the annual figures of 92 and 68 kg N/ cow per year have been obtained by N balance, for large and small animals, respectively; however, these reduce to 83 and 61 kg N/cow per year, after allowing for gaseous N losses from typical production systems. The latter values compare more closely with the previous standard of 58 kg/cow per year. One significant reason for an increase in the figure proposed for the suckler cow is that the calf is now included with the cow.

For turkeys (and other poultry), manures are often exported from the production unit directly from the buildings and so, the N coefficient "ex-house" (i.e., after discounting unavoidable gaseous N losses) seems an appropriate basis for an N production standard - giving 1.36 and 1.02 kg N/bird place/year for male and female turkeys, respectively. This compares with the previous standards of 1.39 and 0.65 kg N/bird place/year for male and female birds.

In all stock types the production cycle and "downtime" for cleaning purposes and re-stocking, has a significant impact on annual N output.

13.4.2 Strength and weakness

The strength of the method used in the United Kingdom is data origin. The review process has included extensive industry consultation, involving producer organisations, specialist consultants, research scientists, industry experts and some farmers. The derived output figures have been compared with the relevant research data available. Recent research data for pigs and poultry have provided useful validation of the proposed outputs and have given confidence both in the values and in the approaches used. Differences with similar standards or recommendations made elsewhere in Europe are generally minor and can usually be understood on the basis of the different feeding practices or management, assumptions made with respect to the composition of 'products', or in the way the figures have been derived.

The relative weakness of the system used is inherent to the method. It is emphasised that there are many influencing factors and the potential variability of any proposed 'standards' means that these figures should be used for general guidance only.

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