

Ammonia emissions from animal manure and inorganic fertilisers in 2009

Calculated with the Dutch National Emissions Model for Ammonia (NEMA)

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Wettelijke Onderzoekstaken Natuur & Milieu

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Working Document 302

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Summary

Table 1 presents data on a number of years of ammonia emissions from agriculture. The series have been calculated with the Dutch National Emissions Model for Ammonia (NEMA) (Velthof *et al.*, 2009; Van Bruggen *et al.*, 2011).

Ammonia emissions from agriculture have decreased by two thirds, since 1990. One of the main reasons for this decrease has been a reduction in nitrogen excretion by farm animals. In 1990 this excretion contained 690 million kilograms of nitrogen (N), an amount that was reduced to 484 million kilograms in 2009. Another reason for the decrease in ammonia emissions has been an increase in the distribution of animal manure outside the agricultural sector, including exports; from 20 million kilograms of nitrogen in 1990, to 64 million kilograms in 2009.

Of the total decline in NH₃ emissions nearly 80% was related to manure spreading. Reductions in the emissions from animal housing and manure storage were responsible for a further 13%. Grazing had a 7% share in the decline and inorganic fertiliser contributed a further 2%.

Table 1. Ammonia emissions from agriculture (million kg NH₃)

| | 1990 | 1995 | 2000 | 2005 | 2008 | 2009 |
|---|--------------|--------------|--------------|--------------|--------------|--------------|
| Dairy cows | | | | | | |
| Housing and storage | 21.6 | 20.0 | 14.3 | 13.9 | 14.3 | 13.8 |
| Pasture | 9.0 | 8.0 | 2.2 | 1.5 | 1.1 | 0.6 |
| Application | 90.3 | 27.6 | 21.4 | 21.4 | 20.3 | 20.5 |
| Total | 120.9 | 55.6 | 37.9 | 36.7 | 35.7 | 34.8 |
| Other cattle | | | | | | |
| Housing and storage | 12.8 | 13.0 | 10.1 | 7.8 | 8.2 | 8.3 |
| Pasture | 7.0 | 6.2 | 2.2 | 1.4 | 0.8 | 0.6 |
| Application | 43.2 | 16.9 | 13.2 | 10.0 | 8.9 | 8.8 |
| Total | 63.0 | 36.1 | 25.4 | 19.3 | 18.0 | 17.7 |
| Other grazing livestock | | | | | | |
| Housing and storage | 1.0 | 1.2 | 1.3 | 1.2 | 1.2 | 1.1 |
| Pasture | 1.8 | 1.7 | 0.7 | 0.4 | 0.3 | 0.2 |
| Application | 1.1 | 1.4 | 1.6 | 1.4 | 1.2 | 1.2 |
| Total | 4.0 | 4.3 | 3.6 | 3.1 | 2.7 | 2.6 |
| Pigs | | | | | | |
| Housing and storage | 34.7 | 33.8 | 24.5 | 17.8 | 18.9 | 19.1 |
| Application | 63.5 | 19.4 | 14.6 | 11.2 | 6.5 | 7.1 |
| Total | 98.3 | 53.3 | 39.1 | 29.0 | 25.4 | 26.2 |
| Poultry, rabbits and fur-bearing animals | | | | | | |
| Housing and storage | 16.3 | 16.2 | 16.9 | 14.1 | 13.6 | 14.1 |
| Application | 16.6 | 7.9 | 8.6 | 5.7 | 3.4 | 2.4 |
| Total | 32.9 | 24.2 | 25.5 | 19.7 | 17.0 | 16.4 |
| Total animal manure | | | | | | |
| Housing and storage | 86.5 | 84.3 | 67.1 | 54.7 | 56.2 | 56.3 |
| Pasture | 17.8 | 16.0 | 5.1 | 3.3 | 2.2 | 1.4 |
| Application | 214.8 | 73.3 | 59.2 | 49.7 | 40.4 | 40.0 |
| Total | 319.1 | 173.5 | 131.5 | 107.8 | 98.9 | 97.8 |
| Inorganic fertiliser | | | | | | |
| | 13.9 | 14.0 | 12.0 | 13.0 | 10.1 | 10.1 |
| Total | 333.0 | 187.5 | 143.5 | 120.8 | 109.0 | 107.9 |

Figure 1 shows the development of NH₃ emissions from animal manure in housing and storage, in pastures, and from manure application. The decline in NH₃ emissions was greatest during the first half of the 1990s, due to implementation of low-emission application techniques. Annual ammonia emission levels are not always lower than those in their preceding year. In 1991, for example, nitrogen excretion levels were higher than in 1990, causing an increase in manure spreading. This included a larger amount of manure being applied to grassland with, on average, higher emission factors. This also occurred in 1993.

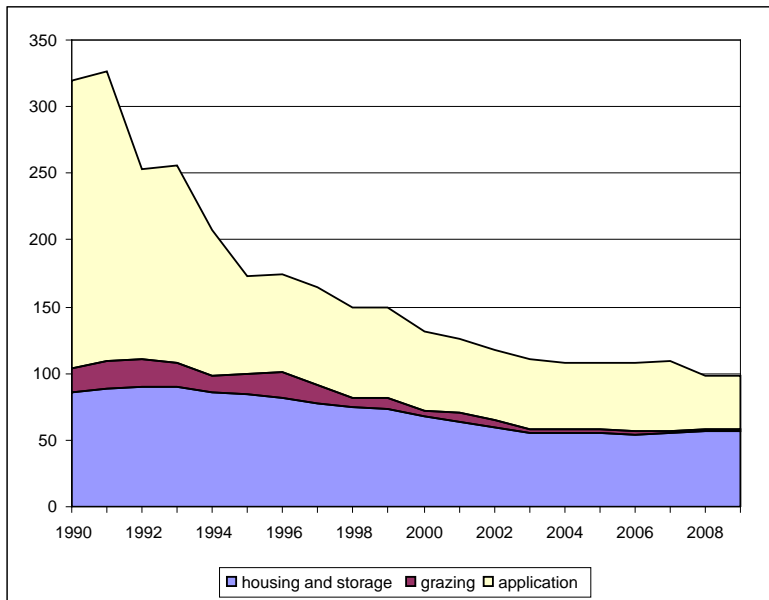


Figure 1. Ammonia emissions from animal manure in agriculture (million kg NH₃)

Figure 2 shows the development of NH₃ emissions in agriculture, per animal category.

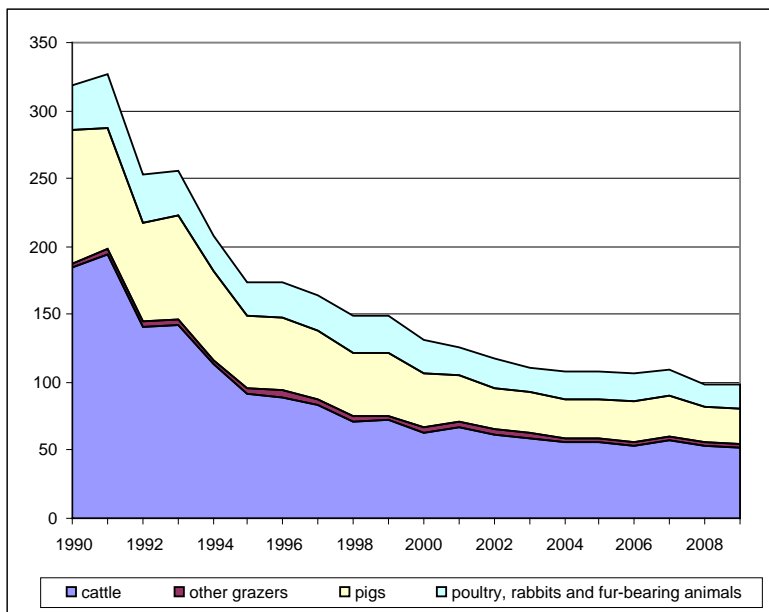


Figure 2. Ammonia emissions from agriculture, per animal category (million kg NH₃)

Ammonia emission levels in 2009 were similar to those in 2008. There was, however, a decrease in emissions in pastures because of the low N content in dairy-cow rations during grazing seasons (Section 2.10) and a shift in manure production from pastures to animal housing (CBS, 2011).

Chapter 4 presents a table with elaborate data on NH₃ emissions from agriculture.

Some animal manure is being produced outside the agricultural sector, such as by horses and ponies that are not included in the agricultural census. In addition, a share of manure is being applied outside the agricultural sector; for example, in nature areas and on hobby farms and private properties. Table 2 presents a summary of ammonia emissions from animal manure and inorganic fertilisers outside the agricultural sector.

Table 2. Ammonia emissions outside the agricultural sector (million kg NH₃)

| | 1990 | 1995 | 2000 | 2005 | 2008 | 2009 |
|-----------------------------|------|------|------|------|------|------|
| Total animal manure | | | | | | |
| Housing and storage | 1.3 | 1.3 | 1.3 | 1.3 | 1.2 | 1.2 |
| Pasture | 0.7 | 0.7 | 0.3 | 0.3 | 0.6 | 0.4 |
| Application | 6.9 | 4.0 | 2.7 | 4.2 | 2.9 | 3.0 |
| Total | 8.9 | 6.0 | 4.3 | 5.8 | 4.7 | 4.6 |
| | | | | | | |
| Inorganic fertiliser | 0.6 | 0.6 | 0.7 | 0.9 | 0.8 | 0.8 |
| | | | | | | |
| Total | 9.5 | 6.7 | 4.9 | 6.7 | 5.5 | 5.4 |

In animal housing and manure storage, in addition to ammonia emissions, other N compounds are also emitted (Table 3). However, indirect emissions of other N compounds formed after manure application on soils are outside the scope of this report.

Table 3. Emission levels of other gaseous nitrogen losses from manure in animal housing and from manure stored outside animal housing (million kg N)

| | 1990 | 1995 | 2000 | 2005 | 2008 | 2009 |
|----------------------------|------|------|------|------|------|------|
| Agriculture | | | | | | |
| N ₂ O | 2.2 | 2.2 | 1.9 | 1.7 | 1.9 | 1.9 |
| NO | 2.2 | 2.2 | 1.9 | 1.7 | 1.9 | 1.9 |
| N ₂ | 13.7 | 13.3 | 11.3 | 10.2 | 11.0 | 11.1 |
| | | | | | | |
| Outside agriculture | | | | | | |
| N ₂ O | 0.2 | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 |
| NO | 0.2 | 0.2 | 0.2 | 0.2 | 0.1 | 0.1 |
| N ₂ | 0.8 | 0.8 | 0.8 | 0.8 | 0.7 | 0.7 |
| | | | | | | |
| Total | | | | | | |
| N ₂ O | 2.4 | 2.4 | 2.1 | 1.9 | 2.0 | 2.0 |
| NO | 2.4 | 2.4 | 2.1 | 1.9 | 2.0 | 2.0 |
| N ₂ | 14.5 | 14.1 | 12.1 | 11.0 | 11.7 | 11.9 |

1 Introduction

This working document is a translation of WOt-working document 251 (in Dutch).

Ammonia emissions from animal manure and inorganic fertiliser in 2009 was calculated using the Dutch National Emissions Model for Ammonia (NEMA). The methodology is described by Velthof *et al.* (2009).

Van Bruggen *et al.* (2011) present the basic assumptions used in calculations of ammonia emissions over the 1990–2008 period.

The current report describes the basic assumptions used in calculations of ammonia emissions of 2009.

2 Basic assumptions animal manure

2.1 Animal numbers

Table 2.1 provides an overview of animal numbers. The numbers for 2009 were obtained from the agricultural census as described in Van Bruggen *et al.* (2011), as are those for the 1990–2008 period.

Table 2.1. Number of animals (x 1,000)

| Animal category | 2008 | 2009 |
|---|--------|--------|
| Dairy and breeding cattle | | |
| Female young stock, 12 months and under | 532 | 577 |
| Male young stock, 12 months and under | 34 | 33 |
| Female young stock, 12 months and over | 589 | 613 |
| Male young stock, 12 months and over, including stud bulls | 23 | 22 |
| Dairy cows | 1,466 | 1,489 |
| Beef cattle | | |
| Fattening calves, in white-meat production | 627 | 625 |
| Fattening calves, in pink-meat production | 272 | 269 |
| Female young stock, 12 months and under | 43 | 41 |
| Male young stock (incl. oxen), 12 months and under | 54 | 53 |
| Female young stock, 12 months and over | 63 | 65 |
| Male young stock (incl. oxen), 12 months and over | 61 | 57 |
| Suckler cows, feedlot cows and grazing cows, 24 months and over | 127 | 123 |
| Ewes | 583 | 538 |
| Dairy goats | 208 | 231 |
| Horses | 93 | 94 |
| Ponies | 51 | 51 |
| Fattening pigs | 5,839 | 5,872 |
| Gilts and young boars | 236 | 253 |
| Sows | 978 | 985 |
| Boars | 8 | 8 |
| Broilers, parent animals of 18 weeks and under | 2,386 | 2,646 |
| Broilers, parent animals of 18 weeks and over | 4,863 | 4,288 |
| Laying hens, 18 weeks and under | 11,508 | 11,347 |
| Laying hens, 18 weeks and over | 33,586 | 35,294 |
| Broilers | 44,358 | 43,285 |
| Meat ducks, including parent animals | 1,064 | 1,157 |
| Turkeys | 1,044 | 1,060 |
| Rabbits (does) | 41 | 41 |
| Mink (female parents) | 849 | 870 |

Source: Agricultural census (Landbouwtelling, CBS, 2011)

NB Not included in the table are animal categories for which the excretion data was incorporated in that on female parents (piglets, male animals, and the young in breeding systems of sheep, goats, rabbits and fur-bearing animals).

2.2 Excretion of N, TAN and P

The working group for uniformity of calculations on manure and nutrient data (*Werkgroep Uniformering berekening Mest- en mineralcijfers* (WUM)) each year calculates N excretions per animal, including the apportionment to housing and grazing seasons. For the calculation of excretion factors per animal, certain animal categories have been combined in order to match the available index numbers on feed use and animal production (WUM, 2010).

In addition to N excretion data, the share in TAN (total ammonia nitrogen) also was determined. Here, TAN has been defined as urine N and mainly consists of urea. In order to determine the TAN excretion, information on N digestibility of animal rations was required. Table 2.2 shows the N digestibility that was used in calculating TAN excretion for 2009. Hardly any changes occurred, compared to the data for 2008. The methodology for determining N digestibility is described in Van Bruggen et al. (2011).

Table 2.2. Faecal nitrogen digestibility of feed (%) in 2009

| | N digestion coefficient |
|--|-------------------------|
| | % |
| Grass silage | 74.6 |
| Grass silage from extensively managed grassland | 72.1 |
| Maize silage | 46.6 |
| Meadow grass | 81.8 |
| Meadow grass of extensively managed grassland | 77.8 |
| Dairy cattle | |
| standard compound feed | 76.7 |
| protein-rich compound feed | 83.5 |
| Beef cattle | |
| Starting feed for beef bulls | 83.3 |
| Finishing feed for beef bulls | 78.8 |
| Starting feed for fattening calves for pink-meat production | 80.0 |
| Finishing feed for fattening calves for pink-meat production | 79.9 |
| Compound feed for pigs | |
| Fattening pigs | 79.4 |
| Gilts | 79.6 |
| Sows, including piglets up to 25 kilograms | 78.3 |
| Boars | 75.1 |
| Compound feed for poultry | |
| Laying hens of 18 weeks and under | 82.0 |
| Laying hens of 18 weeks and over | 84.3 |
| Broilers, parent animals of 18 weeks and under | 80.0 |
| Broilers, parent animals of 18 weeks and over | 81.9 |
| Broilers | 85.3 |
| Meat ducks | 84.6 |
| Meat turkeys | 86.7 |

Sources: Bikker et al. 2011 and WUM

TAN was calculated on the basis of N excretion and N digestibility of rations. Amounts of N and P excretions and shares of TAN for housing and pasture are indicated in Table 2.3. Apportionment of dairy cow excretions to housing and pasture during grazing seasons is described in the following paragraph. For elaboration on changes in data between 2008 and 2009, see CBS (2011).

Table 2.3. N and P excretion (in kg/animal.year) and share of TAN (%), 2009

| | Excretion in animal housing | | | Excretion in pasture ¹⁾ | | |
|---|-----------------------------|-----|-------------------------------|------------------------------------|-----|-------------------------------|
| | N | TAN | P ₂ O ₅ | N | TAN | P ₂ O ₅ |
| Dairy and breeding cattle | | | | | | |
| Female young stock, 12 months and under | 28.8 | 66 | 8.1 | 7.1 | 78 | 1.7 |
| Male young stock, 12 months and under | 33.2 | 62 | 8.3 | | | |
| Female young stock, 12–24 months | 45.0 | 68 | 13.8 | 28.2 | 76 | 8.4 |
| Male young stock, 12–24 months | 84.4 | 70 | 27.1 | | | |
| Female young stock, 24 months and over | 45.0 | 68 | 13.9 | 28.2 | 76 | 8.4 |
| Dairy cows - housing period | 66.0 | 59 | 21.3 | | | |
| Dairy cows - grazing season | 38.2 | 62 | 11.9 | 22.8 | 62 | 7.0 |
| Stud bulls, 24 months and over | 84.4 | 70 | 27.1 | | | |
| | | | | | | |
| Beef cattle | | | | | | |
| Fattening calves, in white-meat production | 10.6 | 65 | 4.4 | | | |
| Fattening calves, in pink-meat production | 28.0 | 58 | 8.9 | | | |
| Female young stock, 12 months and under | 28.4 | 65 | 8.0 | 7 | 79 | 1.7 |
| Male young stock, incl. oxen, 12 months and under | 26.9 | 54 | 7.9 | | | |
| Female young stock, 12–24 months | 44.1 | 68 | 13.6 | 28.6 | 76 | 8.6 |
| Male young stock, incl. oxen, 12–24 months | 54.9 | 60 | 19.0 | | | |
| Female young stock, 24 months and over | 44.1 | 68 | 13.6 | 28.6 | 76 | 8.5 |
| Male young stock, incl. oxen, 24 months and over | 54.9 | 60 | 19.0 | | | |
| Suckler cows, feedlot cows and grazing cows | 37.9 | 65 | 13.0 | 44.9 | 75 | 14.0 |
| | | | | | | |
| Ewes | 1.4 | 66 | 0.5 | 12.5 | 74 | 3.9 |
| Dairy goats | 16.1 | 58 | 6.3 | | | |
| | | | | | | |
| Horses | 30.3 | 73 | 12.0 | 28.2 | 75 | 10.6 |
| Ponies | 13.2 | 74 | 5.1 | 18.9 | 78 | 6.7 |
| | | | | | | |
| Fattening pigs | 12.7 | 68 | 5.1 | | | |
| Gilts and young boars of 50 kg and under | 13.6 | 70 | 6.4 | | | |
| Sows | 30.3 | 65 | 15.1 | | | |
| Young boars 50 kg and over | 13.6 | 70 | 6.4 | | | |
| Boars | 23.2 | 72 | 12.2 | | | |
| | | | | | | |
| Broilers, parent animals of 18 weeks and under | 0.3 | 69 | 0.2 | | | |
| Broilers, parent animals of 18 weeks and over | 1.1 | 77 | 0.6 | | | |
| Laying hens, 18 weeks and under | 0.3 | 75 | 0.2 | | | |
| Laying hens, 18 weeks and over | 0.8 | 78 | 0.4 | | | |
| Broilers | 0.5 | 71 | 0.2 | | | |
| Meat ducks | 0.8 | 70 | 0.4 | | | |
| Turkeys | 2.0 | 77 | 1.0 | | | |
| | | | | | | |
| Rabbits (does) | 7.7 | 70 | 3.8 | | | |
| Mink (female parents) | 1.9 | 70 | 1.0 | | | |

¹⁾ Only applicable to categories of animals with grazing seasons.

Apportionment of dairy cow excretions to housing and pasture

Apportionment of excretions to housing and pasture for 2009 was based on data from the agricultural census 2010, which included data on grazing from 2009. This resulted in information on duration of housing and grazing seasons, and distribution of dairy cows over grazing systems. The grazing systems applied and the duration of daytime grazing together determine the amounts of excretion in animal housing during grazing seasons for dairy cows. Excretion amounts in animal

housing for day and night grazing and for daytime grazing were assumed to be proportional to the number of barn hours (WUM, 2010).

As emission factors are calculated per housing system, the amount of nitrogen excreted within animal housing must be determined for each grazing system applied (unlimited grazing, limited grazing, or full-time housing). It is assumed that tie stalls and compost barns are only used in combination with unlimited grazing (Oenema *et al.*, 2000). This would mean that, during grazing seasons, 15% of excretions by dairy cows ends up inside their housing systems. To determine excretion levels in cubicle housing systems for dairy cows during grazing seasons, the apportionment to grazing systems was corrected for the numbers of tie stalls and compost barns. Subsequently, shares of the excretions within animal housing per grazing system were used for determining the contribution in nitrogen excretion, for cubicle housing, including other housing types not studied (Table 2.4).

Table 2.4. Contribution of grazing systems to N excretions within animal housing during grazing seasons of dairy cows, housed in cubicle housing systems

| Grazing systems | Number of dairy cows (lbt2010) | Share of tie stalls and compost barns (lbt2008) | Share of dairy cows, excl. tie stalls and compost barns | Excretions in housing systems during grazing seasons, per grazing system | Share per grazing system in N excretions within cubicle housing |
|-------------------|--------------------------------|---|---|--|---|
| | % | % | % | % | |
| Unlimited grazing | 22 | 5.8 | 17 | 15 | 4 |
| Limited grazing | 54 | | 58 | 67 | 58 |
| Full-time housing | 24 | | 28 | 100 | 38 |
| Total | 100 | | 100 | | 100 |

Sources: Agricultural census 2010 (Landbouwtelling, (lbt2010)) and 2008 (lbt2008).

2.3 Mineralisation and immobilisation

In calculations of TAN excretion, 10% net mineralisation of organic N excretion was taken into account for liquid cattle and pig manure. It was assumed that such mineralisation takes place immediately following excretion within animal housing. TAN levels and emissions from animal housing may have been slightly overestimated for housing systems that are mucked out regularly.

For solid manure from grazing livestock and pigs, a 25% immobilisation of TAN immediately following excretion was assumed (Van Bruggen *et al.*, 2011).

2.4 Housing of farm animals

For 2009 no new information was available on the housing of farm animals. Therefore, information on animal places related to liquid manure and those related to solid manure was based on data from the agricultural census of 2008. The same is true for degrees of implementation of housing systems and derived emission factors (Van Bruggen *et al.*, 2011).

2.5 Emission factors of N₂O, NO and N₂

Calculations of other gaseous N losses from indoor-produced manure were based on calculations of N₂O emissions according to IPCC guidelines (IPCC, 1996; GPG, 2001) and Oenema et al. (2000). Emission factors per type of manure are elaborated in Van Bruggen et al. (2011).

2.6 Manure storage outside animal housing

Shares of manure stored outside housing systems have not changed from those of 2008, with the exception of poultry litter of broilers and ducks. Shares of exports and incineration were taken into account in the determination of storage of poultry litter outside housing systems. The share of broiler litter stored outside housing systems decreased from 40% in 2008 to 35% in 2009. Storage of duck litter increased from 85% to 90%. Emission factors for manure storage have not been adjusted (Van Bruggen et al., 2011).

2.7 Manure distribution outside agriculture

2.7.1 Introduction

Emissions from manure production or from distribution outside agriculture have been addressed separately in calculations for environmental assessments and apportioned to consumers and consumer services. Examples are emissions from manure from horses not included in the agricultural census, and from manure application on hobby farms, private properties and nature areas.

Manure distribution outside agriculture includes:

- Distribution to hobby farms;
- Distribution to nature areas;
- Distribution to private properties;
- Manure treatment;
- Net export.

Data on manure distribution outside agriculture was based on assumptions and results from the project 'Monitoring the manure market' and from CBS research into manure treatment. For a description of these basic assumptions see Van Bruggen *et al.* (2011). To determine the distribution of phosphate in untreated solid manure, manure distribution volumes were assumed based on transport documentation and phosphate content according to the WUM. Table 2.5 presents an overview of phosphate contents.

Table 2.5. Phosphate content of solid manure (kg P₂O₅/t)

| Type of manure | 2008 | 2009 |
|-----------------------|------|------|
| Horse and pony manure | 2.3 | 2.3 |
| Sheep manure | 2.8 | 3.6 |
| Goat manure | 4.9 | 4.8 |
| | | |
| Laying poultry manure | 21.6 | 22.1 |
| Broiler manure | 17.4 | 17.4 |
| Duck manure | 5.1 | 5.4 |
| Turkey manure | 19.3 | 19.3 |
| Rabbit manure | 9.5 | 10.1 |
| Mink manure | 11.5 | 9.6 |

NB For distribution outside the agricultural sector, mink manure is regarded as solid manure. Source: WUM

2.7.2 Hobby farms

Distribution to hobby farms, as presented in Table 2.6, was based on MAMBO model calculations for the project 'Monitoring the manure market 2009' (Luesink *et al.*, 2010).

Table 2.6. Distribution of animal manure from agriculture to hobby farms (million kg P_2O_5)

| | 2008 | 2009 |
|---|-------|-------|
| Dairy cows - liquid manure | 0.728 | 0.873 |
| Dairy cows - solid manure | 0.000 | 0.070 |
| Young stock, including stud bulls - liquid manure | 0.302 | 0.321 |
| Young stock, including stud bulls - solid manure | 0.083 | 0.087 |
| Beef cattle, excluding fattening calves - liquid manure | 0.063 | 0.202 |
| Beef cattle, excluding fattening calves - solid manure | 0.005 | 0.005 |
| Sheep | 0.000 | 0.027 |
| Fattening calves | 0.303 | 0.137 |
| Fattening pig manure | 0.392 | 0.381 |
| Breeding pigs, liquid manure | 1.625 | 1.526 |
| Laying hens, liquid manure, untreated | 0.000 | 0.000 |
| Rabbits | 0.053 | 0.045 |
| Total | 3.554 | 3.674 |

Source: MAMBO, Monitoring manure market

2.7.3 Nature areas

Total distribution to nature areas has not changed, compared to that in preceding years (Van Bruggen *et al.*, 2011). Apportionment to the animal categories in Table 2.7 was based on phosphate production in manure on pastures.

Table 2.7. Distribution of animal manure from agriculture to nature areas (million kg P_2O_5)

| | 2008 | 2009 |
|---|-------|-------|
| Dairy cattle | | |
| Female young stock, 12 months and under | 0.132 | 0.154 |
| Female young stock, 12–24 months | 0.606 | 0.694 |
| Female young stock, 24 months and over | 0.095 | 0.112 |
| Dairy cows | 1.859 | 1.633 |
| Beef cattle | | |
| Female young stock, 12 months and under | 0.011 | 0.011 |
| Female young stock, 11–24 months | 0.053 | 0.061 |
| Female young stock, 11–24 months and over | 0.023 | 0.027 |
| Suckler cows, feedlot cows and grazing cows | 0.251 | 0.270 |
| Sheep | 0.297 | 0.329 |
| Horses | 0.129 | 0.156 |
| Ponies | 0.045 | 0.054 |
| Total | 3.500 | 3.500 |

Source: MAMBO, Monitoring manure market

2.7.4 Private properties

Distribution to private properties (Table 2.8) was derived from transport documentation on animal manure. Distribution data includes manure pellets and spent mushroom compost (SMC). The relative small distribution of manure pellets to private properties is regarded to have been poultry manure.

Distribution of SMC was apportioned to horse manure and poultry manure based on the shares of these manure types in the production of substrate for mushroom cultivation. The share of horse manure was corrected for the share of companies that are not registered as agricultural businesses, and was estimated at two thirds of the total. Distribution of poultry manure in the form of SMC was apportioned to laying poultry and meat poultry, in proportion to the share of these manure types in the production of mushroom substrate, according to CBS research on manure treatment 2009.

Table 2.8. Distribution of animal manure from agriculture to private properties (million kg P₂O₅)

| | 2008 | 2009 |
|--|--------------|--------------|
| Dairy cows - liquid manure | 0.399 | 0.427 |
| Sheep | 0.005 | 0.005 |
| Goats | 0.015 | 0.012 |
| Horses and ponies (untreated manure) | 0.010 | 0.020 |
| Horse and pony manure in SMC | 0.015 | 0.016 |
| Fattening calves | 0.081 | 0.103 |
| Fattening pig manure | 0.589 | 0.704 |
| Breeding pig manure | 0.372 | 0.392 |
| Poultry manure, including manure pellets | | |
| Laying poultry liquid untreated manure | 0.000 | 0.000 |
| Laying poultry solid untreated manure | 0.033 | 0.014 |
| Broilers (untreated manure) | 0.016 | 0.002 |
| Ducks (untreated manure) | 0.002 | 0.001 |
| Turkeys (untreated manure) | 0.000 | 0.000 |
| Laying poultry manure in SMC | 0.014 | 0.016 |
| Broiler manure in SMC | 0.020 | 0.019 |
| Manure pellets | 0.020 | 0.034 |
| Rabbits | 0.003 | 0.002 |
| Mink | 0.008 | 0.005 |
| Total | 1.602 | 1.772 |

Sources: Transportation documentation animal manure (National Service for the Implementation of Regulations (Dienst Regelingen)) and CBS research into manure treatment.

2.7.5 Manure treatment

Manure is removed from the agricultural sector by certain manure treatment processes, such as liquid calve-manure treatment systems and manure incineration. However, certain manure treatment methods may also add to the amount of 'animal manure'. For instance, in the case of manure fermentation; its end-product (digestate) also contains N and P₂O₅ from co-substrates that were added to animal manure to increase the output of the fermentation process. Other products may also be added in the composting of manure. In the determination of manure distribution, both within and outside the agricultural sector, no account was taken of possible increases or decreases in the amounts of animal manure caused by certain forms of manure treatment, such as fermentation. Also,

on balance, no removal of nitrogen or phosphate occurs during other manure treatment methods, such as manure separation combined with ultrafiltration.

Manure treatment products that are being distributed abroad have been included under exports.

Although, based on sampled data from liquid calve-manure treatment, an increase or decrease in the amount of phosphate may occur, the overall amount of phosphate in the treatment process stays the same. The balance, therefore, was set to zero. Data on liquid calve-manure treatment were obtained from the CBS research into manure treatment. In 2009, 1.35 million kilograms of nitrogen was removed in liquid calve-manure treatment.

The DEP power station in Moerdijk, in 2009, processed 3.2 million kilograms of phosphate in manure from broilers and turkeys, and 4.5 kilograms of phosphate in manure from laying hens, according to transport documentation on animal manure.

2.7.6 Net exports

Export data was based on transport documentation. All of the exported cattle manure was considered to be liquid manure from dairy cows, including cakes and filtrate after manure separation, and solid cattle manure (manure codes 10 to 14). Nitrogen export was calculated by multiplying exported phosphates with the average N:P₂O₅ ratio.

Export of spent mushroom compost (SMC) consisted mainly of poultry manure and that of horses and ponies. Total production of SMC was considered equal to the amount of this compost removed from agricultural businesses, hobby farms and other businesses, on the basis of transport documentation. The share of exported SMC, which is around 76%, could also be deduced from this documentation. Information on the amounts of poultry manure and horse manure that have been processed into substrate for mushroom cultivation was obtained from the CBS research into manure treatment. The shares of chicken and broiler manure in processed poultry manure are known. Their export in the form of SMC could be calculated by multiplying the processed amounts of phosphate (based on transport information) with the export share.

Export of horse-manure-related SMC was corrected for the amount of manure that would have come from horses not included in the agricultural census. This involves imported horse manure and nationally produced horse manure that does not originate from agricultural businesses. It was estimated that around one third of Dutch horse manure originated from agricultural businesses (Hoogeveen et al., 2010, Appendix 5). Export of agriculture-related horse manure in the form of SMC (phosphate), therefore, was calculated thus: (total processed horse manure minus imports) * 1/3 * export share * WUM content.

In addition to the export of agriculture-related horse manure in the form of SMC, there is also the export of untreated horse manure. It was assumed that, for the export of this manure, also one third originated from agricultural businesses. All imported horse manure was assumed subsequently to be exported in the form of SMC. The share of animal manure in the export of other compost and sewage treatment sludge was considered negligible.

All export of mink manure was calculated as being solid manure. Data on exported liquid mink manure was converted into data on solid manure by halving manure volumes (Hoogeveen et al., 2010 p.109).

Export of manure pellets in packages up to 25 kilograms is not included in transport documentation, as such documentation is not required for packages of this size. Distribution levels of manure pellets in small packages were derived from the supply of animal manure to treatment facilities and the

registered output in manure pellets. Inquiries at a number of manure treatment facilities have shown that close to all manure pellets are exported. The distribution of these pellets was apportioned to laying poultry, meat poultry and cattle, on the basis of results from CBS research on manure treatment.

Export of treated and untreated manure is presented in Table 2.9.

Table 2.9. Net export of treated and untreated animal manure from the agricultural sector (million kg P₂O₅)

| | 2008 | 2009 |
|--|---------------|---------------|
| Dairy cows - liquid manure | 0.454 | 0.551 |
| Goats | 0.003 | 0.005 |
| Horses and ponies (untreated manure) | 0.033 | 0.044 |
| Horse and pony manure in SMC | 0.454 | 0.392 |
| Fattening calves | 0.035 | 0.031 |
| Fattening pig manure | 1.977 | 3.757 |
| Breeding pig manure, liquid | 2.300 | 1.489 |
| Poultry manure, including manure pellets | | |
| Laying poultry, liquid manure, untreated | 0.000 | 0.000 |
| Laying poultry, solid manure, untreated | 9.368 | 9.823 |
| Broilers (untreated manure) | 4.035 | 2.937 |
| Ducks (untreated manure) | 0.049 | 0.037 |
| Turkeys (untreated manure) | 0.604 | 0.493 |
| Laying poultry manure in SMC | 0.520 | 0.497 |
| Meat poultry manure in SMC | 0.728 | 0.593 |
| Manure pellets/dried | 2.572 | 2.882 |
| Rabbits | 0.043 | 0.053 |
| Mink and foxes | 0.277 | 0.289 |
| Total | 23.453 | 23.873 |

Sources: Transportation documentation animal manure (National Service for the Implementation of Regulations (Dienst Regelingen)) and CBS research into manure treatment.

2.8 Manure application

2.8.1 Apportionment to grassland and arable land

The amount of nitrogen and phosphate applied to soils was calculated from data on manure production, gaseous losses from housing and storage, stock mutations and distribution outside the agricultural sector. Apportionment of manure from housing and storage to grassland and arable land in 2009, presented in Table 2.10, was based on that in the Monitoring of the manure market 2009.

Table 2.10. Application on grassland and arable land of animal manure from manure storage (%)

| | 2008 | | 2009 | |
|---------------------------------|-----------|-------------|-----------|-------------|
| | Grassland | Arable land | Grassland | Arable land |
| Manure shares | 47.5 | 52.5 | 48.7 | 51.3 |
| Share per type of manure | | | | |

| | 2008 | | 2009 | |
|-------------------------|-----------|-------------|-----------|-------------|
| | Grassland | Arable land | Grassland | Arable land |
| Cattle | | | | |
| Dairy cows | 68.8 | 16.0 | 68.9 | 17.2 |
| Young stock | 11.2 | 8.0 | 10.2 | 10.6 |
| Other cattle | 4.6 | 3.1 | 4.4 | 2.9 |
| Fattening calves | 3.1 | 5.2 | 1.7 | 7.0 |
| Other grazing livestock | 2.9 | 2.6 | 2.8 | 3.1 |
| Fattening pigs | 2.7 | 39.7 | 5.2 | 37.5 |
| Breeding pigs | 6.2 | 15.3 | 6.5 | 16.5 |
| Poultry | | | | |
| Laying poultry | 0.1 | 3.3 | 0.1 | 1.1 |
| Meat poultry | 0.0 | 5.3 | 0.0 | 2.4 |
| Other confined animals | 0.4 | 1.4 | 0.3 | 1.7 |
| Total | 100 | 100 | 100 | 100 |

Source: MAMBO, Monitoring manure market

2.8.2 Implementation of application techniques

In the agricultural census 2010, participants were queried about manure application of 2009. Results have been included in Van Bruggen *et al.* (2011). Table 2.11 presents data on the application techniques used in 2009. These data were also used for 2008.

For the calculation of application emissions, the various types of manure were first apportioned to grassland and arable land, based on results from Monitoring of the manure market (Section 2.8.1). A description of the method used for apportioning the application of liquid and solid manure to grassland and arable land to the various techniques, can be found in Van Bruggen *et al.* (2011).

Table 2.11. Share of application techniques (%)

| | 2009 | | |
|--------------------------------------|---------|---------------|--------------|
| | average | liquid manure | solid manure |
| Grassland | | | |
| Shallow injection | 56 | 60 | - |
| Partly injection, partly narrow band | 12 | 13 | - |
| Trailing shoe and hose | 23 | 25 | - |
| Surface spreading | 9 | 3 | 100 |
| Total | 100 | 100 | 100 |
| Arable land | | | |
| Deep placement | 61 | 68 | - |
| Shallow injection | 8 | 9 | - |
| Trailing shoe and hose | 6 | 7 | - |
| Partly injection, partly narrow band | 7 | 8 | - |
| Surface incorporation in one track | 3 | 3 | - |
| Surface incorporation in two tracks | 11 | 5 | 62 |
| Surface spreading | 4 | - | 38 |
| Total | 100 | 100 | 100 |

Source: Agricultural census of 2010.

2.9 Emission factors of manure application

For information on the methods used for determining the emission factors in Table 2.12, see Velthof *et al.* (2009) (Appendix 14) and Van Bruggen *et al.* (2011).

Table 2.12. Emission factors of manure application (% of TAN)

| Emission factor | 2009 |
|--------------------------------------|------|
| Shallow injection | 19 |
| Partly injection, partly narrow band | 22.5 |
| Trailing shoe and -hose | 26 |
| Surface spreading (grassland) | 74 |
| Surface spreading (arable land) | 69 |
| Deep placement (arable land) | 2 |
| Surface incorporation in one track | 22 |
| Surface incorporation in two tracks | 46 |

2.10 Ammonia emissions during grazing

Calculation of ammonia emissions during grazing is described in Velthof *et al.* (2009, Section 4.6 and p.151). The emission factor is dependent on the average nitrogen content of dairy cow rations during grazing seasons. The calculated emission factor for TAN excretion from dairy cows during grazing was applied to all grazing livestock categories. Because of the large amount of maize silage in 2009 rations, the emission factor related to grazing was set at 2.7%. Over the 2006–2008 period, the emission factor was around 3.5% (Van Bruggen *et al.*, 2011).

3 Inorganic fertiliser

The calculation of the average emission factor for inorganic fertiliser was based on distribution data (LEI inorganic fertiliser statistics) and emission factors for ammonia per type of inorganic fertiliser (Velthof *et al.*, 2009; Appendix 16). Figures on total distribution were subsequently corrected for non-agricultural destinations, such as hobby farms and private properties.

The study by Luesink *et al.* (2011) is the first to have taken into account the inorganic fertiliser distribution with non-agricultural destinations, such as private properties, departments of public parks and gardens, and garden centres. Annual distribution was estimated at five million kilograms of nitrogen.

Annual distribution of inorganic fertiliser to hobby farms was estimated at 12.4 million kilograms of nitrogen, calculated for an area size of 150,000 hectares and inorganic fertiliser application of half the amount used on grassland in the late 1990s (Luesink *et al.*, 2011).

At the time of calculation of the ammonia emissions for 2009, distribution data on inorganic fertiliser for that year were not yet available. Therefore, the provisional figure on its distribution for 2009 was set to that of 2008.

Table 3.1. Inorganic fertiliser use (1,000 kg N) and average emission factor (% of N)

| | 2009* |
|--|---------|
| Ammonium nitrate | 0 |
| Ammonium sulphate | 12,804 |
| Ammonium sulphate nitrate | 4,684 |
| Sodium nitrate | 0 |
| Ammonium bisulphate | 0 |
| Mixed nitrogen compound fertiliser | 5,854 |
| Potassium nitrate | 0 |
| Calcium ammonium nitrate | 156,802 |
| Calcium nitrate | 0 |
| Monoammonium phosphate | 0 |
| Other NPK, NP and NK-compound fertiliser | 42,767 |
| Nitrogen phosphate potassium magnesium compound fertiliser | 7,054 |
| Nitromagnesite | 1,416 |
| Urea | 6,731 |
| Liquid ammonia | 0 |
| Sulphur-coated urea | 0 |
| Non-specified products | 0 |
| Total distribution | 238,112 |
| specified into: | |
| Agriculture and horticulture | 220,712 |
| Hobby farms | 12,400 |
| Private property owners and others | 5,000 |
| Average emission factor (%) | 3.8% |

*provisional figure, equal to the distribution in 2008.

4 Results

Table 4.1 presents average emission factors for NH₃-N from liquid and solid manure in animal housing, per animal category. The influence of grazing systems applied (for dairy cattle) and low-emission application techniques has been taken into account in the calculation of emission factors. The emission factor for grazing are provided in Section 2.10.

Table 4.2 presents ammonia emission data on a number of years.

Table 4.1. Emission factors for NH₃-N from animal housing (% of TAN excretion)

| | Liquid manure | Solid manure |
|---|---------------|--------------|
| Dairy cows - housing period | 10.2 | 10.5 |
| Dairy cows - housing during grazing season | 12.4 | 33.2 |
| Female young stock, up to 24 months (including beef cattle) | 11.2 | 11.7 |
| Male young stock and stud bulls | 11.7 | 11.7 |
| Fattening calves in white-meat production | 25.8 | |
| Fattening calves in pink-meat production | 11.9 | |
| Beef bulls | 18.5 | 18.5 |
| Suckler cows, feedlot cows and grazing cows | 15.1 | 15.1 |
| Sheep | | 27.8 |
| Goats | | 17.1 |
| Horses | | 19.5 |
| Ponies | | 29.0 |
| Fattening pigs | 20.5 | |
| Gilts and young boars | 22.5 | |
| Sows | 19.7 | 19.7 |
| Boars | 25.4 | 25.4 |
| Broilers, parent animals of 18 weeks and under | | 80.3 |
| Broilers, parent animals of 18 weeks and over | | 45.9 |
| Laying hens, 18 weeks and under | 8.98 | 22.5 |
| Laying hens, 18 weeks and over | 13.6 | 16.0 |
| Broilers | | 19.5 |
| Young meat ducks | | 29.7 |
| Turkeys | | 35.6 |
| Rabbits | | 54.3 |
| Mink | 8.01 | |

Table 4.2. Ammonia emissions from agriculture (million kg NH₃)

| | 1990 | 1995 | 2000 | 2005 | 2008 | 2009 |
|--|-------|------|------|------|------|------|
| Cattle | 183.9 | 91.8 | 63.4 | 56.0 | 53.7 | 52.6 |
| Housing and storage | 34.4 | 33.0 | 24.4 | 21.7 | 22.6 | 22.0 |
| Housing | 30.8 | 30.6 | 23.3 | 20.8 | 21.7 | 21.2 |
| Storage | 3.5 | 2.4 | 1.1 | 0.8 | 0.8 | 0.8 |
| Pasture | 16.0 | 14.2 | 4.4 | 2.9 | 2.0 | 1.2 |
| Application | 133.5 | 44.6 | 34.5 | 31.4 | 29.2 | 29.3 |
| Dairy cows | 120.9 | 55.6 | 37.9 | 36.7 | 35.7 | 34.8 |
| Housing and storage | 21.6 | 20.0 | 14.3 | 13.9 | 14.3 | 13.8 |
| Housing | 19.4 | 18.7 | 13.8 | 13.4 | 13.9 | 13.3 |
| Storage | 2.2 | 1.3 | 0.5 | 0.5 | 0.5 | 0.5 |
| Pasture | 9.0 | 8.0 | 2.2 | 1.5 | 1.1 | 0.6 |
| Application | 90.3 | 27.6 | 21.4 | 21.4 | 20.3 | 20.5 |
| Young stock incl. stud bulls | 41.2 | 22.8 | 16.2 | 11.6 | 11.1 | 11.1 |
| Housing and storage | 6.8 | 6.9 | 5.5 | 4.0 | 4.5 | 4.6 |
| Housing | 5.9 | 6.3 | 5.1 | 3.8 | 4.2 | 4.3 |
| Storage | 0.9 | 0.7 | 0.4 | 0.2 | 0.3 | 0.3 |
| Pasture | 5.6 | 4.7 | 1.7 | 1.1 | 0.6 | 0.5 |
| Application | 28.8 | 11.1 | 9.1 | 6.5 | 6.0 | 6.1 |
| Meat calves | 4.1 | 2.7 | 3.5 | 3.2 | 3.1 | 3.0 |
| Housing and storage | 1.5 | 1.8 | 2.2 | 2.0 | 2.1 | 2.1 |
| Housing | 1.5 | 1.8 | 2.2 | 2.0 | 2.1 | 2.1 |
| Storage | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Pasture | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Application | 2.6 | 0.9 | 1.3 | 1.3 | 1.0 | 0.9 |
| Suckler cows, feedlot cows and grazing cows | 3.6 | 3.1 | 2.4 | 2.0 | 1.5 | 1.4 |
| Housing and storage | 0.7 | 0.9 | 0.9 | 0.7 | 0.6 | 0.6 |
| Housing | 0.6 | 0.9 | 0.8 | 0.7 | 0.6 | 0.5 |
| Storage | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 |
| Pasture | 0.8 | 0.9 | 0.4 | 0.3 | 0.2 | 0.1 |
| Application | 2.1 | 1.2 | 1.2 | 1.0 | 0.7 | 0.7 |
| Other beef cattle | 14.1 | 7.5 | 3.2 | 2.5 | 2.3 | 2.2 |
| Housing and storage | 3.8 | 3.3 | 1.5 | 1.1 | 1.0 | 1.0 |
| Housing | 3.4 | 3.0 | 1.4 | 1.0 | 1.0 | 0.9 |
| Storage | 0.4 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 |
| Pasture | 0.6 | 0.6 | 0.1 | 0.1 | 0.1 | 0.0 |
| Application | 9.7 | 3.7 | 1.6 | 1.3 | 1.2 | 1.1 |
| Sheep and goats | 3.0 | 3.0 | 2.2 | 1.7 | 1.6 | 1.4 |
| Housing and storage | 0.7 | 0.7 | 0.8 | 0.6 | 0.6 | 0.5 |
| Housing | 0.6 | 0.6 | 0.7 | 0.6 | 0.5 | 0.5 |
| Storage | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Pasture | 1.7 | 1.5 | 0.6 | 0.3 | 0.2 | 0.1 |
| Application | 0.7 | 0.8 | 0.9 | 0.7 | 0.8 | 0.7 |
| Horses and ponies | 0.9 | 1.3 | 1.3 | 1.4 | 1.1 | 1.2 |
| Housing and storage | 0.3 | 0.4 | 0.5 | 0.6 | 0.6 | 0.6 |
| Housing | 0.3 | 0.4 | 0.4 | 0.5 | 0.5 | 0.5 |
| Storage | 0.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Pasture | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 |
| Application | 0.4 | 0.6 | 0.7 | 0.7 | 0.5 | 0.5 |

| | 1990 | 1995 | 2000 | 2005 | 2008 | 2009 |
|--|-------|-------|-------|-------|-------|-------|
| Pigs | 98.3 | 53.3 | 39.1 | 29.0 | 25.4 | 26.2 |
| Housing and storage | 34.7 | 33.8 | 24.5 | 17.8 | 18.9 | 19.1 |
| Housing | 34.2 | 33.4 | 24.3 | 17.5 | 18.6 | 18.8 |
| Storage | 0.6 | 0.5 | 0.2 | 0.3 | 0.3 | 0.3 |
| Application | 63.5 | 19.4 | 14.6 | 11.2 | 6.5 | 7.1 |
| Fattening pigs | 66.3 | 35.6 | 25.6 | 19.6 | 17.8 | 18.1 |
| Housing and storage | 22.8 | 22.8 | 16.0 | 12.1 | 13.4 | 13.5 |
| Housing | 22.4 | 22.5 | 15.9 | 11.9 | 13.2 | 13.2 |
| Storage | 0.4 | 0.3 | 0.1 | 0.2 | 0.2 | 0.2 |
| Application | 43.5 | 12.8 | 9.6 | 7.5 | 4.4 | 4.7 |
| Breeding pigs | 32.0 | 17.7 | 13.5 | 9.4 | 7.7 | 8.1 |
| Housing and storage | 12.0 | 11.1 | 8.5 | 5.7 | 5.5 | 5.7 |
| Housing | 11.7 | 10.9 | 8.4 | 5.6 | 5.4 | 5.5 |
| Storage | 0.2 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 |
| Application | 20.0 | 6.6 | 5.0 | 3.8 | 2.1 | 2.4 |
| Poultry | 32.3 | 23.5 | 24.9 | 19.1 | 16.6 | 16.1 |
| Housing and storage | 15.8 | 15.9 | 16.6 | 13.8 | 13.3 | 13.8 |
| Housing | 14.7 | 14.5 | 15.3 | 12.3 | 12.0 | 12.4 |
| Storage | 1.1 | 1.3 | 1.3 | 1.4 | 1.3 | 1.4 |
| Application | 16.5 | 7.6 | 8.3 | 5.3 | 3.3 | 2.3 |
| Laying poultry | 21.3 | 15.5 | 14.3 | 8.9 | 9.6 | 9.2 |
| Housing and storage | 9.4 | 8.9 | 9.8 | 8.1 | 8.4 | 8.8 |
| Housing | 8.9 | 8.3 | 9.1 | 7.2 | 7.3 | 7.6 |
| Storage | 0.5 | 0.6 | 0.6 | 0.9 | 1.1 | 1.2 |
| Application | 12.0 | 6.6 | 4.5 | 0.8 | 1.2 | 0.4 |
| Meat poultry | 11.0 | 8.0 | 10.6 | 10.2 | 7.0 | 6.9 |
| Housing and storage | 6.4 | 7.0 | 6.8 | 5.7 | 4.9 | 5.1 |
| Housing | 5.8 | 6.3 | 6.1 | 5.2 | 4.7 | 4.9 |
| Storage | 0.6 | 0.7 | 0.7 | 0.5 | 0.2 | 0.2 |
| Application | 4.6 | 1.1 | 3.8 | 4.5 | 2.1 | 1.8 |
| Rabbits and fur-bearing animals | 0.6 | 0.6 | 0.6 | 0.6 | 0.4 | 0.4 |
| Housing and storage | 0.5 | 0.4 | 0.3 | 0.3 | 0.3 | 0.2 |
| Housing | 0.5 | 0.3 | 0.3 | 0.3 | 0.3 | 0.2 |
| Storage | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Application | 0.1 | 0.3 | 0.2 | 0.3 | 0.1 | 0.1 |
| Total animal manure | 319.1 | 173.5 | 131.5 | 107.8 | 98.9 | 97.8 |
| Housing and storage | 86.5 | 84.3 | 67.1 | 54.7 | 56.2 | 56.3 |
| Housing | 81.0 | 79.9 | 64.3 | 52.0 | 53.6 | 53.6 |
| Storage | 5.4 | 4.4 | 2.8 | 2.7 | 2.7 | 2.7 |
| Pasture | 17.8 | 16.0 | 5.1 | 3.3 | 2.2 | 1.4 |
| Application | 214.8 | 73.3 | 59.2 | 49.7 | 40.4 | 40.0 |
| Inorganic fertiliser | 13.9 | 14.0 | 12.0 | 13.0 | 10.1 | 10.1 |
| Total | 333.0 | 187.5 | 143.5 | 120.8 | 109.0 | 107.9 |

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