Agriculture, Ecosystems and Environment 218 (2016) 232–244

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

Feed use and nitrogen excretion of livestock in EU-27

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ARTICLE INFO

Article history:
Received 22 May 2015
Received in revised form 26 November 2015
Accepted 27 November 2015
Available online 10 December 2015

Keywords:
Animal feed
Cattle
Pigs
Poultry
Manure
Nitrogen excretion

ABSTRACT

Livestock excreta is a large source of nitrogen (N) in the European Union (EU), used to fertilize crops, and also a main source of ammonia (NH_3), nitrous oxide (N_2O) and nitrate (NO_3^-) losses to the environment. The amount of N in excreta mainly depends on the animal category and productivity, and on feed use and management. National inventories of emissions to the environment are often based on different methodologies for the estimation of N excretion. Here, we present a transparent and uniform methodology for estimating annual feed use and N excretion per animal category for all countries of the EU-27, based on the energy and protein requirements of the animals and statistics of feed use and composition, animal number and productivity.

The calculated total feed use in the EU-27 was 506 Tg dry mass in 2010. Dairy cows used 29%, other cattle 34%, pigs 17%, chicken 9%, sheep and goats 8%, and other animal categories 3% of the total feed use. Grass and annual forages were mainly used by dairy cows (30 and 49%, respectively) and other cattle (55 and 44%); pigs used most of the feed cereals (53%); protein-rich feed (e.g., soybean meal) were mostly used by pigs (34%) and chicken (24%). Differences between countries in feed use were large, mainly related to variations in national feed supply and animal productivity. Total N excretion of the animals amounted to 9.7 Tg in 2010, and varied between countries from 14 to 291 kg ha^{-1} of utilized agricultural land. The present study provides a uniform and transparent approach for evaluating feed use and N excretion in all countries of the EU-27. Our results underline the significant differences in N excretions between EU countries as a result of feed use variations, suggesting the need for basing N excretion estimations on feed use data. The dataset present in this study may serve as a basis for such efforts, also to improve national inventories of N emissions.

1. Introduction

The livestock sector is a key user of natural resources, including land, water, nutrients and biomass. Recent estimates suggest that 4.7–7.0 billion tonnes dry biomass is used by livestock, equivalent to nearly 60% of the global plant biomass use (Herrero et al., 2013; Krausmann et al., 2008; Wirsenius et al., 2010). A similar estimate (60–65%) is reported for Europe (Krausmann et al., 2008). The livestock sector also contributes approximately 40% to the global anthropogenic ammonia (NH_3) and nitrous oxide (N_2O) emissions (Galloway et al., 2004; Oenema et al., 2005). In Europe, livestock contributes as much as 80% to the total NH_3 emissions (EEA, 2014), and about 40% to the total N_2O emissions (Bellarby et al., 2013; Oenema et al., 2014). In addition, over use of livestock manure results in leaching of nitrates to groundwater and surface water in Europe (Velthof et al., 2014).

Animal production is projected to continue growing in the next decades, driven by human population growth, rising incomes and dietary preferences towards 'western' diets (Steinfeld et al., 2010; Thornton, 2010). The expansion of animal production, feed use and associated environmental impacts will increase the pressures on natural ecosystems further, unless large improvements are being made in animal productivity, manure handling and manure nutrient recycling (Kastner et al., 2012; Tilman and Clark, 2014; Wirsenius et al., 2010). Strategies such as improvements in feed quality and management, low-emission animal housing and manure management, and timing and rate of N application can greatly abate the growing pressure on the environment (Thornton and Herrero, 2010; Wirsenius et al., 2010). To that end, knowledge and quantitative information on feed use and nutrient excretion

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http://dx.doi.org/10.1016/j.agee.2015.11.025
0167-8809/

rates of the animals, depending on regional resource availability, is crucial for the development of sustainable agro-ecosystems.

Feed composition and animal productivity have significant influences on nitrogen (N) excretion, and on N emissions downstream in the manure management chain (Hou et al., 2015; Oenema et al., 2009; Olesen et al., 2006). International and national statistics (e.g., Eurostat and FAO statistics) provide national data on animal production and animal number per animal category annually. However, animal category-specific data on feed use and composition and on nutrient excreta are usually not available at regional or national levels, and therefore have to be collected or estimated. Various approaches are being used to estimate feed use and N excretion. The N balance approach covers both aspects of feed intake and animal production, i.e., the N excretion is equal to the total amount of feed N consumed minus the N retained in animal products (e.g., milk, eggs and live-weight gains). This approach has been widely employed in field and farm scale research, and benefits from timely measured feed composition and production performance (Arriaga et al., 2010; Galassi et al., 2010; O'Connell et al., 2006; Philippe et al., 2012, 2009). Further, efforts have been made to scale up this N balance approach to regional and national scales, based on estimates of regional and category specific feed use, to support national inventories of N emissions (Bai et al., 2014; Velthof et al., 2012; Webb, 2001). Most of these national-level studies have focused on a single animal category. However, only national studies that include all animal categories would allow to check the feed balance; do the total supplies of feed resources in a country indeed match with the sum of the estimated national feed use by all animal categories, within acceptable ranges of uncertainty?

The overall objective of our study was to provide a uniform approach for the estimation of feed use and N excretion rates of the animals in EU-27 through linking statistical data on feed quality and quantity with energy and protein requirements per animal category at country levels. Firstly, we developed a uniform method for the estimation of animal category-specific average feed use per country, as function of animal productivity and feed availability. Secondly, we estimated the N excretion rates of individual animal categories using the N balance approach. Thirdly, sensitivity analyses were carried out to get quantitative insight in the effect of changes of several methodological parameters on the feed use and N excretion. We then discussed regional variations in feed use and N excretion, and compared our results with national inventories, and also discussed the implication of our study.

2. Materials and methods

2.1. Concept

The methodology developed here aims at deriving animal category-specific and country-specific N excretion coefficients through linking statistical data and information on the availability (quantity and quality) of feed with animal numbers, and the energy and protein requirements of the animals. Animal categories included dairy cows, other cattle, sheep and goats, pigs, laying hens, broilers, turkey and other poultry, i.e., similar to the main categories in the Farm Structure Survey (FFS), used by all countries of the EU-27. The methodology developed in this study is described schematically in Fig. 1. We started by estimating the feed energy required for each animal category per country, considering animal

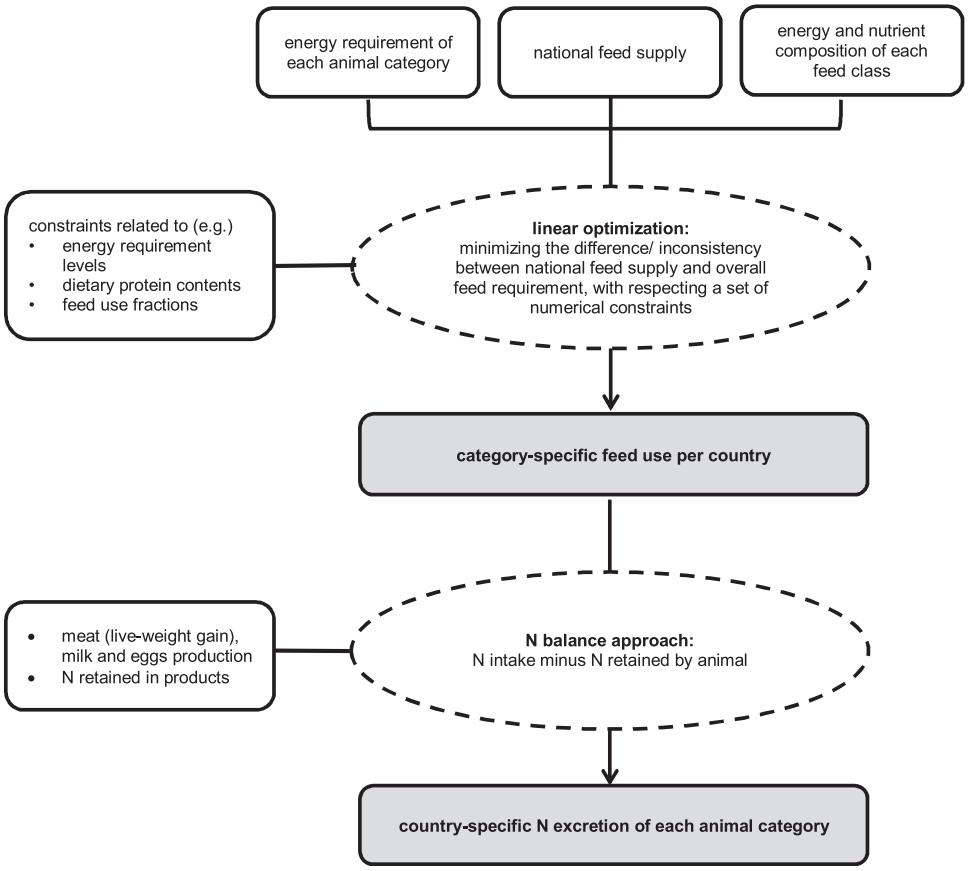

Fig. 1. A simplified schematic representation of the information flow in calculating country-specific feed use and nitrogen (N) excretion of each animal category. The arrows depict the information flow direction. Information as data and parameter input to the model are sketched in top and left boxes. Results are indicated in the shaded boxes, which are gained through the calculations indicated in dashed circles.