A FARM LEVEL AMMONIA EMISSION MODEL FOR INVENTORY PURPOSES IN FLANDERS (BELGIUM)

P. Demeyer (1), D. Foqué (1), P. Boeckx (2), J. Dewulf (3) and H. Van Langenhove (3)

(1) Institute for Fisheries and Agricultural Research (ILVO), Technology & Food Unit, B. Van Gansberghelaan 115, 9820 Merelbeke, Belgium; (2) Ghent University, Department of Applied Analytical and Physical Chemistry, Coupure Links 653, 9000 Gent, Belgium; (3) Ghent University, Department of Sustainable Organic Chemistry and Technology, Coupure Links 653, 9000 Gent, Belgium

Corresponding author email: peter.demeyer@ilvo.vlaanderen.be

ABSTRACT

To meet its European inventory duties, Flanders (Belgium) used until 2009 a straight forward model on regional scale which is based on the number of animals per animal category and on farmland use. Over the years, the Flemish legislation has changed considerably, making an update of this model necessary. Also, a farm and location based approach has become obligatory in view of IPPC regulations. Our new model uses the database of the Flemish Land Agency (VLM), which provides detailed information at farm level with about 47,000 annual manure returns, including manure collection points and processing firms. With this extra information it is possible to assess all manure flows in Flanders. This new model also considers more varied animal housing types, including obligatory emission low systems, and new information on external fertilizer storage. A link with GIS allows to present emission data at farm level, per km^2 and per municipality.

1. INTRODUCTION

The European NEC Directive (2001/81/EC) imposed emission ceilings for some major air pollutants including ammonia. With 1990 as a reference year, Belgium has to reduce it's ammonia emissions to 74 ktons per year by 2010. For Flanders this means a maximum emission of 45 ktons. This limit must be met in principal by the Flemish agricultural sector since it stands for over 90% of the emissions. Europe requires from Flanders also annual emission reports at sector level together with the projections for 2010. The coming review of the NEC directive will also include emission ceilings for 2020.

To meet its Europe reporting duties, the Flemish Environment Agency (VMM) used up to now a mathematical model that was developed by the Ghent University (Pollet, 1996). This model is build on the number of animals per animal category and the farmland use, as indicated in surveys by the National Institute of Statistics (NIS). Based on these data, emissions were calculated from animal houses, manure storage sites, pastures and field application of animal manure and chemical fertilizers. The "Pollet-model" was updated annually, providing new statistics and regular adaptations in view of changing agricultural practices. Doing so the model was reviewed to calculate the emissions on city and village level and some emission factors got changed. However, the Flemish legislation changed considerably since 1996 and of course science also evolved. So an update of this model was necessary and in 2007 the VMM gave ILVO (Institute for Agricultural and Fisheries Research, Technology and Food Unit – research domain Agricultural Engineering) the order to optimize the ammonia emission model for agriculture. The project was conceived as the development of a modified model for the period 1990 (reference year) to 2000 and a new model for the following years with an application horizon of 2020 regarding the review of the NEC directive. In consultation with the client MS Excel was selected as the development platform. This project was performed in cooperation with the Ghent University.

2. METHODOLOGY

A first step within the project involved the updating of the old model for 1990-2000. This update was still based on the NIS statistics at the municipal level. The estimates of the ammonia losses were strongly reviewed for the following emission stages: stables, external storages and the chemical fertilizer use. More different housing types and related emission factors were considered for cattle and poultry. The emissions from external storage were now calculated based on a study performed by Ecolas and the Ghent University (2006). The chemical fertilizer use was calculated using the municipal pasture and cropland areas and related to the respective agricultural region (Campens & Lauwers, 2002). The corresponding emission factors for 4 different types of fertilizers were based on Demeyer (1993) and van der Hoek (2002).

The second new model starts were EMAV2000 finished using the year 2000 as a verification between the two models. As mentioned, this model has an application horizon of 2020. The NIS data were no longer used as the input of the model. Instead a much more detailed information source was used coming from a more recent database of the Flemish government (Flemish Land Agency, VLM). This database works at farm level and is fed by some 47,000 annual manure returns including manure collecting points and manure processing firms. Of course this gives a much more accurate picture of manure production and movement in Flanders. This information treasure combined with a customized calculation method allowed ILVO to develop a second modular and user friendly computer model: EMAV2020. This model uses the following variables at farm level: animal numbers and gross N production per animal category, number and types of low emission animal housings, farmland surfaces and use of chemical fertilizers. These last data were corrected as suggested by Campens & Lauwers (2002) until more reliable statistics become available for each specific agricultural region.

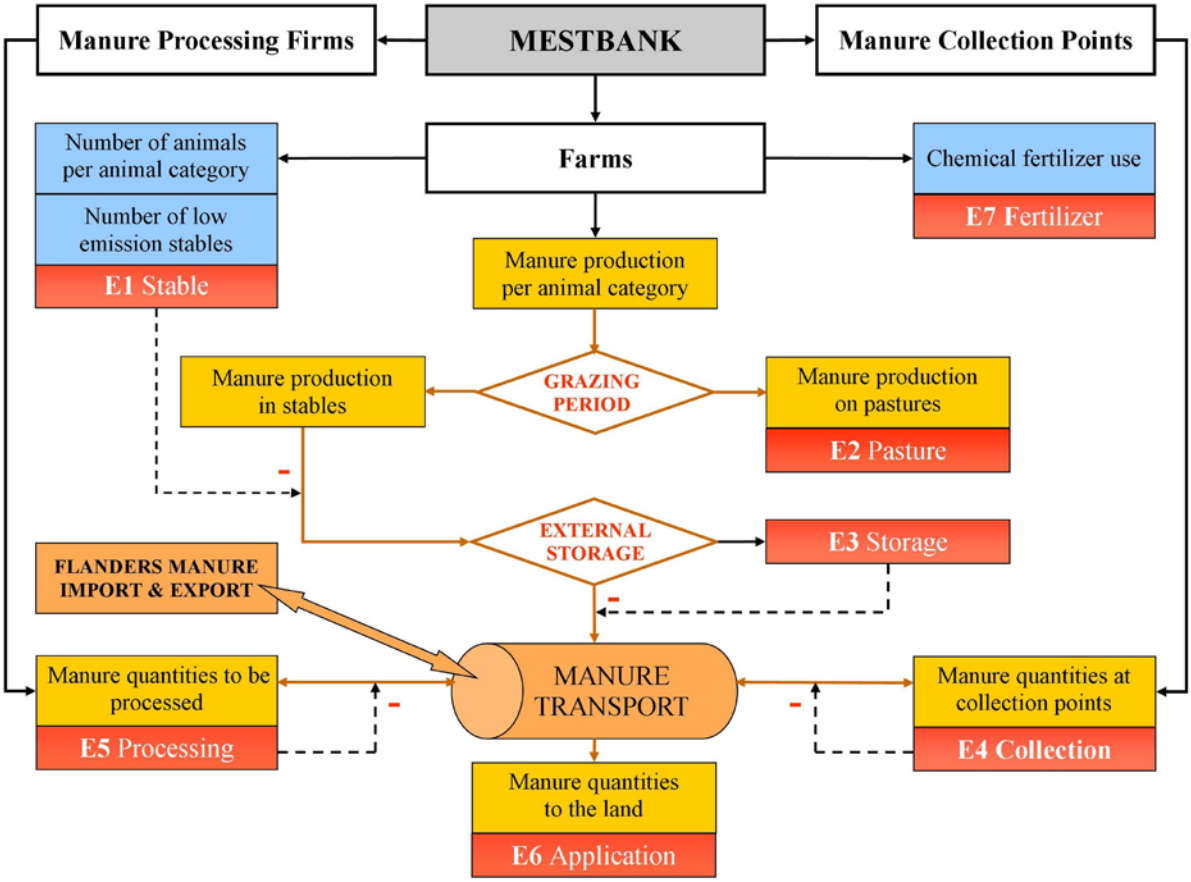

Figure 1: Model build up of EMAV2020 starting from the VLM data (MESTBANK) with the 3 types of firms (Farms, Manure Processing Firms, Manure Collection Points), the used information, the manure flows (brown arrows) and the 7 emission stages indicated in red (E1-E7). The dotted lines indicate were the calculated N losses are used as corrections for the respective manure quantities.

In addition to the farms, the new model approach includes now also all manure collection points and processing firms as individual entities. With this extra information and through analysis of all manure transports within (and also in and out of) Flanders, it was possible to assess the manure flows to these two new emission stages. By calculating the mass balances, the quantities of manure applied to the land could sequentially be calculated. The emissions from the manure treatment plants were calculated using production information from the VCM (Flemish coordination center for manure treatment) and the emission factors as listed in the recent BAT study by VITO (Lemmens et al., 2007). Currently, no data are available for emissions from collection points so these were set to zero in the model.

Figure 1 gives a schematic model flow of EMAV2020 indicating the used information, the manure flows and the 7 emission stages. The latter are respectively emissions from: (1) manure production and storage in

stables, (2) manure production on pastures, (3) external manure storage facilities, (4) collection points for manure, (5) manure processing firms, (6) manure application to the field and (7) application of chemical fertilizers to the field.

3. RESULTS

This first new model for the period 1990-2000 allows simulations in a relatively simple manner. Changes in calculation and emission factors are easily translated using VBA-macro's into a new model output for the various emission stages. The model also provides in custom reporting for the emission stages, for every municipality and for each animal species. This allows visualization of the geographical emission data using GIS (ArcMap 9.2). This new model for the period 1990 to 2000 was named EMAV2000 (Dutch abbreviation for "Emission Model Ammonia Flanders).

The second new model, EMAV2020, has a transparent and modular design and results again in relatively easy simulation exercises which can be used for policy purposes. Different scenarios can be simulated whereby, for instance, the effect is tested of an increase in emission low animal houses. The model provides also in custom reporting of the data per emission stage and per animal species. A link with GIS is provided using the Lambert coordinates of the firms in order to present the emissions data at farm level, per km^2, per municipality and for the whole of Flanders. Hereby the emissions are as closely as possible assigned to their location of origin. This farm and location based approach was also necessary in view of the obligatory EU reports regarding IPPC exploitations (from 40.000 chickens on, or 2.000 finishing pigs, or 750 sows). Such a location specific approach goes without saying with the necessary precautions to comply with privacy protection laws. In order to do so, all individual farms and firms were given a fictional and therefore non traceable serial number by the VLM before the data was sent to ILVO. Figure 2 gives the ammonia emission levels in 2005 for Flanders and per square kilometer. The project was concluded with a Monte Carlo simulation to assess the uncertainties of the model for the two main emission stages (stables and land application).

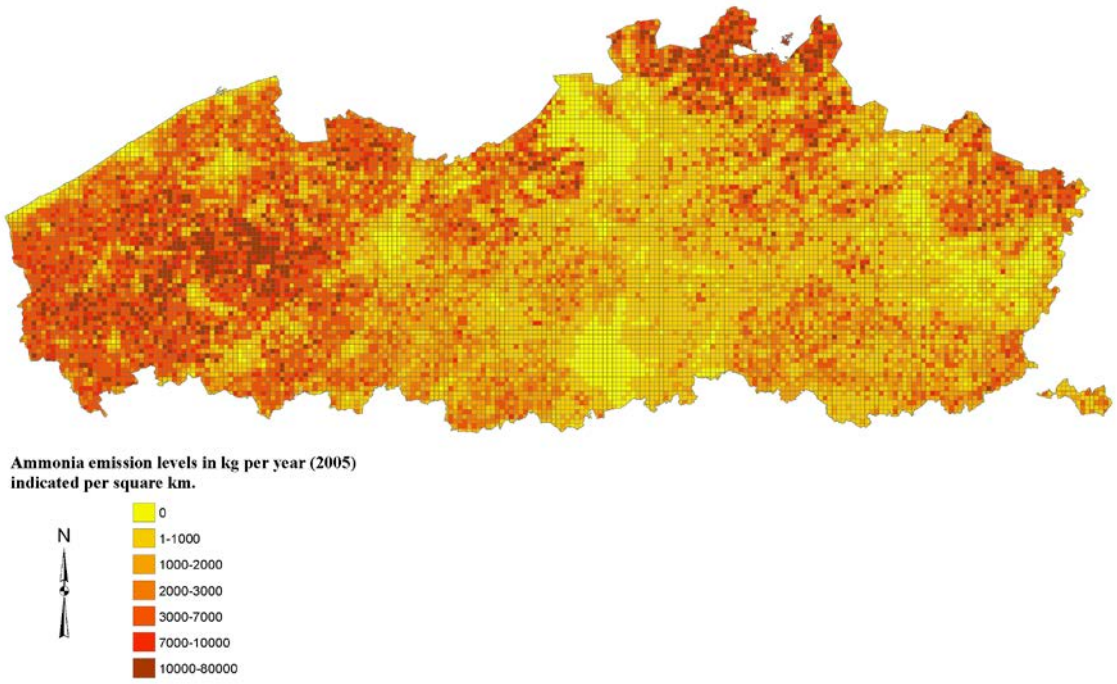

Figure 2: Ammonia emission levels in 2005 for Flanders and per square kilometer.

4. ACKNOWLEDGEMENTS

This work was financed by the Flemish Environment Agency (VMM). We also wish to acknowledge the Flemish Land Agency (VLM) for providing the data and technical assistance.

5. REFERENCES

Campens, V. & Lauwers, L. 2002. Kunstmest en gewasproductie als activiteiten van de nutriëntenemissie, studie uitgevoerd in opdracht van de Vlaamse Milieumaatschappij, MIRA, MIRA/2002/03, Centrum voor Landbouweconomie.

Ecolas & UGent, 2006. Externe mestopslag: inventarisatie van opslagsystemen en bepaling van ammoniak-, lachgas- en methaanemissies uit deze systemen. Studie uitgevoerd in opdracht van LNE, Afdeling Lucht, Hinder, Risicobeheer, Milieu & Gezondheid en Departement Landbouw en Visserij, Afdeling Monitoring & Studie (04/09277/KDV).

Demeyer, P. 1993. Ammoniakvervluchtiging uit de bodem na toediening van ureum- en Ammoniumhoudende meststoffen. Proefschrift voorgedragen tot het bekomen van de graad van Doctor in de Landbouwkundige Wetenschappen**.**

Lemmens, B., Ceulemans, J., Elslander, H., Vanassche, S. & Vrancken, K. 2007. Beste Beschikbare Technieken (BBT) voor mestverwerking - derde editie. Studie uitgevoerd door het Vlaams Kenniscentrum voor Beste Beschikbare Technieken (VITO) in opdracht van het Vlaams Gewest. 1-414.

Pollet, I., Van Langenhove, H. & Christiaens, J. 1996. Onderzoeks- en ontwikkelingsovereenkomst inzake de NH3-emissies door de landbouw, theoretische onderbouw en verantwoording van de berekeningen (deel 1). Onderzoek in opdracht van de Vlaamse Milieumaatschappij uitgevoerd door de Universiteit Gent. 193 p.

van der Hoek, K.W. 2002. Uitgangspunten voor de mest- en ammoniak-berekeningen 1997 tot en met 1999 zoals gebruikt in de Milieubalans 199 en 2000 RIVM rapport 773004012/2002.