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Emission Inventory of Agriculture in Germany

Reporting on emissions is a main part of various international agreements. To generate the so called emission inventories, sufficient knowledge about sources and quantities must be available. The Federal Research Institute for Rural Areas, Forestry and Fisheries (vTI) and the Association for Technology and Structures in Agriculture (KTBL) compile the agricultural emission inventory in Germany every year.

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Keywords

Emission inventories, ammonia emissions, methane emissions, nitrous oxide emissions

Literature

References can be called up under LT 08412 per Internet www.landtechnik-net.de/literatur.htm .

With the ratification of international protocols (UN ECE CLRTAP[1]), UNFCCC[2]), NEC[3])), Germany has committed itself to regular reports on the emissions of greenhouse gases and other components polluting the environment. This applies to all sectors of origin including agriculture. This reporting has to meet severe quality criteria. If these cannot be met, sanctions may be applied, such as exclusion from the so-called clean development mechanisms (including emission trading). In Germany, the Federal Ministry for Environment, Nature Conservation and Nuclear Safety is responsible for emission reporting. As yet, agricultural emission reporting serving the various protocols has been carried out by the Federal Research Institute for Rural Areas, Forestry and Fisheries (vTI, in charge) and by the Association for Technology and Structures in Agriculture (KTBL).

These inventories assess

- the emissions of methane (CH_4), carbon dioxide (CO_2), non-methane volatile organic compounds (NMVOC) including their carbon and sulfur contents (NMVOC-C and NMVOC-S), ammonia (NH_3), nitrous oxide (N_2O), nitric oxide (NO), di-nitrogen (N_2) as well as particles (total suspended particles, TSP, and fine particles PM_{10} and $PM_{2.5}$) from soils, crop production, animal husbandry and forestry,
- CH_4 deposition to soils,
- carbon pools and their variation with time
- the uncertainties of emissions and carbon stocks

The compilation of the inventories also includes the establishment of projections. These have to be delivered every fifth year. However, national policy makers require projections annually.

In addition, the international protocols also ask for a verification of emission reducing measures and measures to increase sink capacities for atmospheric carbon as well the effect on air quality and environmental loads of such measures.

Procedure

The assessment of emissions and carbon pools is achieved by models, which describe these entities in a way with a sufficient resolution in time and space that emission reduction measures and the improvement of carbon sinks can be deduced, respectively. This presupposes knowledge of the relevant German activity data and carbon stocks as well as of appropriate German emission factors and functions. The fluxes of nitrogen and carbon species are depicted in a mass flow model in a way that reflects agricultural practice as a whole.

The modelling of emissions and depositions (of CH_4) as well of the stocks and their variation reflects of the state of science and the guidance documents provided by UNECE (EMEP/CORINAIR 2002) and UNFCCC (IPCC 1996, 2000) as well as the requirements of the EU (e.g. NEC Directive) with respect to

- transparency
- completeness
- consistency
- comparability and
- accuracy and uncertainty.

The mass flow model considers single source categories that are homogeneous and recordable. The guidance documents mentioned above are the methodological backbone of the calculation procedures. It takes into account that key sources, such as dairy cows, are described in great detail, whereas marginal sources, such as goats, are dealt with using simpler methodologies. A simpler methodology combines the respective activity (here: the number of animals, n_{goat}) with an emission factor for the species considered (here CH_4 from manure man.) $EF_{CH4,\ manure\ man.,\ goat}$, in order to obtain the respective emission $E_{CH4,\ manure\ man.,\ goat}$ according to

$$E_{CH4,\ manure\ man.,\ goat} = n_{Ziege} \cdot EF_{CH4,\ manure\ man.,\ goat}$$

The emission factors to be used in the different world regions are listed. They are con-

[1]) UN ECE Convention on Long-Range Transboundary Air Pollution, http://www.unece.org/env/lrtap
[2]) UN Framework Concention on Climate Change, Kyoto Protocol, http://unfccc.int
[3]) National Emission Ceilings, Official Journal of the European Union L 309//22, 27.11.2001

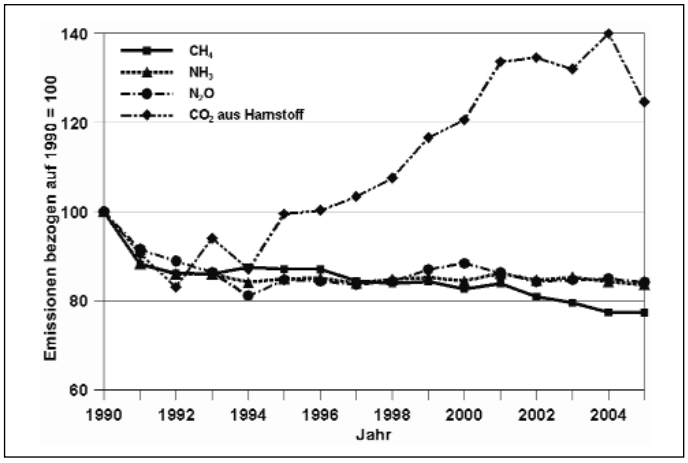

Fig. 1: Trend of emissions from German agriculture, base year 1990

stant with time and space (within a region) ("default emission factors"). In Germany, this procedure is applied in few cases only, e.g. with goats as mentioned above or for N_2O emissions from histosols. As a rule, national data referring to the typical German situation are used. In animal husbandry, excretions are quantified, and the emissions related to the amount excreted. Thus, the actual activity is the product of animal number n_{goat} and $N_{excretion}$ mn, goat from which the emission is deduced:

$$E_{NH3,goat} = (n_{goat} \cdot m_{N,\ goat}) \cdot EF_{NH3,\ goat}$$

This procedure is called *improved* methodology.

Finally, a *detailed* methodology makes use of animal excretions in faeces and in urine as a function of animal performance and feed. The emission factors take housing and keeping, storage systems as well as application techniques and times before incorporation into account. For storage and application, air temperatures may be considered.

The reporting obligations include the compilation of a key source analysis which valuates sources according to their contribution to the national total as well as their trend. Key sources have to be treated using detailed methodologies (if these are available). For greenhouse gases, key sources in agriculture are

- methane emissions from enteric fermentation of cattle
- methane emissions from manure management in cattle and pig husbandry
- direct and indirect nitrous oxide emissions from soils.

For ammonia

- manure management in cattle, pig, horse and poultry husbandry
- application of mineral fertilizers

were identified as key sources.

Both pig and cattle husbandries are considered key sources for NMVOC emissions. The degree of detailing of the methods involved in the compilation of the German emission inventory is related to the availability of data and expert knowledge. However, the model used (GAS-EM) can also be used to quantify (typical) emissions from single sources, e.g. from single farms.

Sources dealt with in the agricultural inventory

A detailed description is provided in [2]. This brochure describes which gases and particles are considered for which source, how complex the procedure used is and what resolution in space and time can be provided at present. The important factor for the resolution in space is the availability of the respective animal numbers. Often, the emission factors are less resolved.

Origin of activity data

Basic data sets of activities are the official statistics provided by the Federal Statistical Office (Statistisches Bundesamt) and the statistical offices of the Federal States (Statistische Landesämter). The time series provided suffer from the change in time of the agricultural censuses. Thus, the series are inconsistent in principle. For sheep and horses, deviations require corrections [1]. In some cases animal categories officially reported have to be transformed in order to achieve excretion data depending on animal performance; this applies to calves, heifers, male beef cattle, weaners, pullets and laying hens.

At present, some of these time series are incomplete due to data protection regulations and have to be completed accordingly. Performance data can be extracted from the literature, some are provided by e.g. animal breeders' associations. Many important data (such as frequency distributions of housing and storage types or application details) have to be modelled using special evaluations of official data, data from surveys and expert judgement. Here, the procedure described six years ago [7] has been applied up till now. However, the availability of data has changed for the worse.

The German agricultural emission inventory for the year 2005

The inventory for the year 2005 was accomplished in September 2006. A detailed description of the procedures as well as the emissions, the activity data, the additional emission explaining data and the implied emission factors are now available in the web [2, 6].

The emission inventory provides complete time series for each of these data. They are recalculated every year making use of the then present state of knowledge. *Figure 1* illustrates the trend of the overall emissions of some important species. It also shows that after the consolidation of agriculture in the New Länder emissions decrease marginally only. Although animal numbers have decreased steadily, emission factors have increased. For dairy cows, e.g., the mean grazing time per animal (grazing causes small NH_3 emissions) decreased, milk yield and animal weights have increased. CO_2 emissions from urea application indicate the increasing use of this fertilizer; urea application leads to relatively large ammonia emissions.

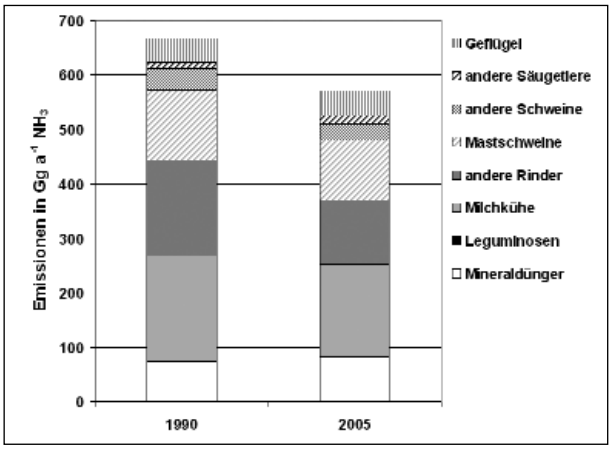

Fig. 2: Ammonia emissions from agriculture in Gg per year in 2005 compared with the emission in 1990 (base year)

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