EVOLUTION OF AMMONIA EMISSIONS IN SWITZERLAND BETWEEN 1990 AND 2007

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1 INTRODUCTION

Within the framework of the Convention on Long-range Transboundary Air Pollution and its protocols (UN/ECE, 1999), Parties have to regularly report their emissions and to achieve national emission ceiling values. Since 1999 ammonia (NH_3) is included as an air pollutant in the Gothenburg Protocol covering the time period 1990 to 2010. The target for Switzerland according to this protocol is a reduction of ammonia emissions by 13%. NH_3 emission inventories for Switzerland were therefore compiled and published by Stadelmann et al. (1998) for 1990 and 1995 and by Reidy et al. (2008) for 1990, 1995, 2000 and 2003. Since in all considered years, agriculture contributed with about 93-95% to the total national NH_3 emissions, these inventories had a special focus on agriculture. While expert assumptions for activity data on structural and management parameters were used for 1990 and 1995, emissions from 2002 onwards were based on data from representative farm surveys.

National emission ceilings are set in the Gothenburg Protocol for 2010. A new representative farm survey was therefore carried out in winter 2007/2008 to establish an updated time series on emissions and provide baseline data for the negotiations on a revised Protocol for the time period beyond 2010. A special objective was to study the influence on NH_3 emissions of the new agricultural policy and direct payment program introduced since 1994 with clear environmental and animal welfare requirements.

2 MATERIALS AND METHODS

2.1 Representative farm survey for activity data

The approach chosen to collect activity data for 2007 from a representative sample of farms was basically the same as described by Reidy et al. (2008). A twelve page questionnaire on livestock and manure management was distributed to a random sample of 6565 farms stratified according to three geographical regions (East, Central, West/South), three altitude zones (valley, hills, mountains) and five farm types. All in all, 3133 questionnaires (i.e. 48% of the distributed questionnaires) could be included in the data analysis. The Federal Office for Statistics provided activity data on livestock numbers and farming surface for these farms in an anonymous form. For 2002 the original data from Reidy et al. (2008) could be used. More information on the farm survey is given in Kupper et al. (2010a).

2.2 Emission calculations

Emission calculations for 2007 and 2002 were individually made for each farm included in the analysis using the model AGRAMMON (Kupper et al. 2010b). As the model DYNAMO used by Reidy et al. (2008), AGRAMMON is a nitrogen (N) flow model that calculates emissions for grazing, housing, manure storage and application for 24 livestock categories. For each of the 32 classes of the survey (region x altitude x farm type) and for each livestock category an average emission factor per animal per year for grazing, housing, storage and application was calculated. These mean emission factors were used for upscaling emissions to the national level by multiplying them with animal numbers of the respective classes. Emissions could be assigned to the municipality level and mapped in a km^2 grid resolution. For 1990 and 1995 a simplified calculation at the national scale was performed. Due to the difference in the applied methodology a full homogeneity of the emission time series cannot be assured.

3 RESULTS AND DISCUSSION

3.1 Emissions in 2007

Total NH_3 emissions in 2007 were 52.3 kt N with a 94% contribution from agriculture (49.0 kt N).Within agriculture livestock production and manure management contributed to 90% (43.9 kt N), the rest coming from mineral N fertilizers (2.3 kt N), organic fertilizers (0.3 kt N) and crop surfaces (2.4 kt N; including grassland). Cattle, pigs and poultry contributed to 79%, 15% and 3%, respectively, of the emissions from livestock production and manure management. The distribution between grazing, housing, manure storage and application was 3%, 34%, 16% and 47%, respectively.

3.2 Development of emissions between 1990 and 2007

Total anthropogenic emissions declined by 13% between 1990 (59.3 kt N) and 2007, agricultural NH_3 emissions by 14% and emissions from livestock and manure management by 11% (Figure 1). The lowest level of agricultural emissions was reached in 2004 (47.5 kt N).

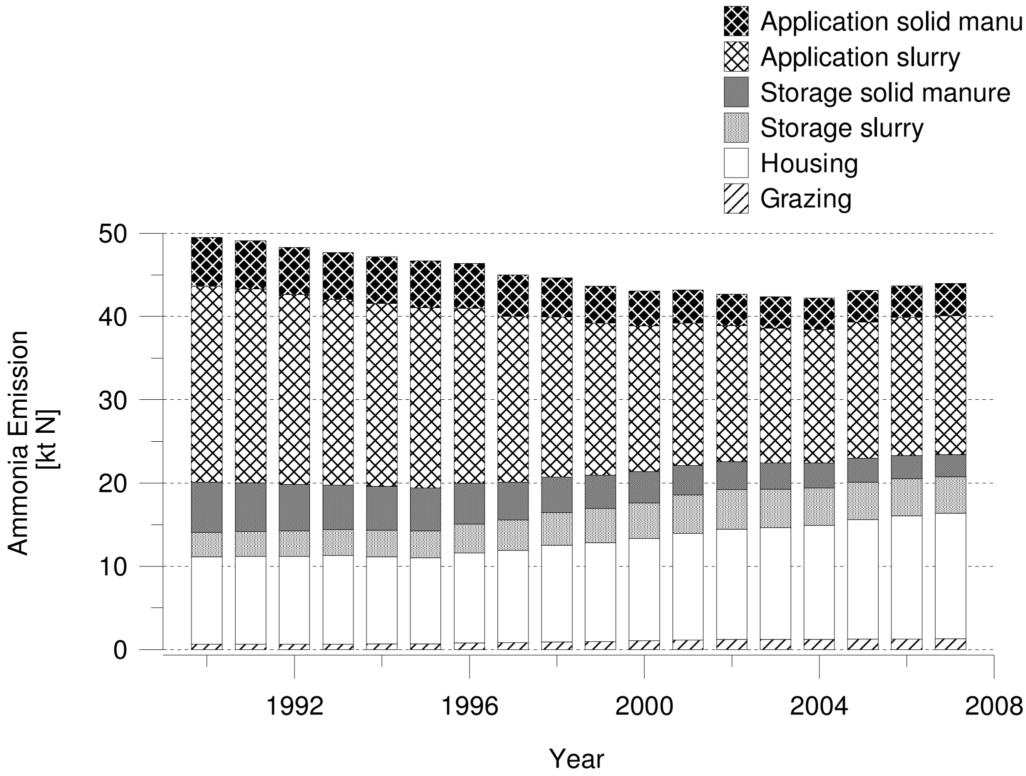

FIGURE 1 **Development of NH_3 from livestock production and manure management between 1990 and 2007 divided to grazing, housing, manure storage and application**

The strong increase in loose housing systems and exercise yards for cattle was due both to the new compulsory animal welfare regulation in the direct payment program and economic/labour considerations. A similar development was observed for pigs due to market driven label programs leading to over 60% of the fattening pigs now being kept in housing systems with multi-area pens with littered areas and outside exercise yard. According to Swiss measurements (Berry et al., 2005) these systems produce twice as much emissions as conventional housings with partly or fully slatted one-area pens. These developments for cattle and pigs led to an increase of housing emissions by 44% between 1990 and 2007 (Figure 1).

Consequently, the N flow per dairy cow into storage was reduced by about 6% in spite of the over 40% increase in milk yield. For fattening pigs the N flow into storage was reduced by 41% due to an approximately 30% reduction in excretion per animal place thanks to a combination of feeding measures, change in genetic potential and higher housing emissions. Due to the reduced N flow from livestock, the sum of storage and application losses were reduced by approximately 30% between 1990 and 2007 with a clear shift towards higher emissions from liquid manure and a decrease from solid manure due to changing housing systems.

Emissions from crop production decreased by about 30% between 1990 and 2007 mainly thanks to a decrease of mineral fertilizer use as a consequence of the farm-related nutrient balance requirements.

4 CONCLUSIONS

The national ammonia emission target of a 13% reduction between 1990 and 2010 according to the Gothenburg Protocol can probably just be reached, provided that emissions do not further increase until 2010. This or even a certain reduction can be expected since voluntary programs for emission mitigation measures with financial assistance have recently been introduced in different Cantons.

The development of emissions was influenced in different ways by the new agricultural policy and the related direct payments program introduced in the mid nineties. On the one hand animal welfare requirements led to a strong increase of housing emissions. These were largely compensated by lower storage and application losses resulting from the reduction of the N flow due to increased grazing and higher housing emissions. On the other hand the farm-related nutrient balance regulation leads to a limitation of animal numbers, lower N excretions of pigs thanks to feeding measures, more careful use of manure to minimize losses and a reduction of mineral fertilizer use. The mechanisms of these interactions must still be analyzed in more detail.

With the increase in housing emissions, the share of the stationary and more or less constant emissions during the year from housings and storage have increased from 39% in 1990 to 50% in 2007. This shift, together with the relatively small overall decrease of calculated national emissions of 13% between 1990 and 2007 and some open questions with respect to the homogeneity of the emission time series might partially explain why the available time series of the annual averages of measured concentrations and wet depositions of reduced N compounds do not show a significant downward trend (NABEL 2009). From 2000 onward the monitoring network is substantially denser than in the previous decade and the temporal trends of the measured concentrations and wet depositions correspond well with the calculated emission trends (Thöni and Seitler 2009).

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REFERENCES

Berry N, Zeyer K, Emmenegger L, Keck M 2005. Emissionen von Staub (PM10) und Ammoniak (NH_3) aus traditionellen und neuen Stallsystemen mit Untersuchungen im Bereich der Mastschweinehaltung. Agroscope FAT Tänikon, Eidg. Forschungsanstalt für Agrarwirtschaft und Landtechnik, CH-8356 Ettenhausen, Empa , Eidg. Materialprüfungs- und Forschungsanstalt, Überlandstrasse 129, CH-8600 Dübendorf. 108 p.

Kupper T, Bonjour C, Bohnenblust D, Achermann B, Menzi H 2010a. Assessment of farm and manure management in Switzerland by means of representative stratified surveys. In: *Treatment and use of organic residues in agriculture: Challenges and Opportunities towards sustainable management. Cordovil C M d S et al.* (eds.). 14th Int Conf Europ Coop Res FAO ESCORENA Network on recycling of agricultural municipal and industrial residues in agriculture Ramiran'08. Liasabon, Protugal, September 13th-15th 2010 (this volume).

Kupper T, Bonjour C, Zaucker F, Achermann B, Menzi H 2010b. Agrammon: An internet based model for the estimation of ammonia emissions. In: *Treatment and use of organic residues in agriculture: Challenges and Opportunities towards sustainable management. Cordovil C M d S et al.* (eds.). 14th Int Conf Europ Coop Res FAO ESCORENA Network on recycling of agricultural municipal and industrial residues in agriculture Ramiran'08. Liasabon, Protugal, September 13th-15th 2010 (this volume).

NABEL 2009. Air quality 2008, measurement results of the National Observation Network on Air Pollutants (NABEL). Swiss Federal Office for the Environment and EMPA.

Reidy B, Rhim B, Menzi H 2008. A new Swiss inventory of ammonia emissions from agriculture based on a survey on farm and manure management and farm-specific model calculations. Atmos. Environ. 42(14): 3266-3276.

Stadelmann F X, Achermann B, Lehman H J, Menzi H, Pfefferli S, Sieber U, Zimmermann A 1998. Ammonia Emissions in Switzerland: Present Situation, Development, Technical and Economic Assessment of Abatement Measures, Recommendations. Institut fuer Umweltschutz und Landwirtschaft Liebefeld (IUL) und Forschungsanstalt fuer Agrarwirtschaft und Landtechnik (FAT), 56 p.

Thöni L, Seitler E 2009. Ammoniak-Immissionsmessungen in der Schweiz 2000 bis 2008. FUB – Forschungsstelle für Umweltbeobachtung. Rapperswil,, 48 p.

UN/ECE 1999. Protocol to the 1979 Convention on Long- Range Transboundary Air Pollution to abate acidification, eutrophication and ground-level ozone. United Nations Economic Commission for Europe (UNECE), Geneva.