Schrade S., Zeyer K., Emmenegger L., Vollmer M.K., Keck M. and Hartung E. 2007: Ammonia emissions in naturally ventilated cattle housing with an exercise yard: requirements and measuring concept using two tracer gases. In: Ammonia emissions in agriculture. Proceedings of the First Ammonia Conference 19-21 March 2007, Ede, The Netherlands, p. 345-346.

Ammonia emissions in naturally ventilated cattle housing with an exercise yard: requirements and measuring concept using two tracer gases

S. Schrade[1], K. Zeyer[2], L. Emmenegger[2], M.K. Vollmer[2], M. Keck[1], E. Hartung[3]
[1] Agroscope Reckenholz-Tänikon ART, Tänikon, CH-8356 Ettenhausen, Switzerland
[2] Empa, Swiss Federal Laboratories for Materials Testing and Research, Überlandstrasse 129, CH-8600 Dübendorf, Switzerland
[3] Christian-Albrechts-University Kiel, Institute of Agricultural Engineering, Max-Eyth-Str. 6 D-24118 Kiel, Germany

Keywords: ammonia, emission, cattle housing, measuring concept, tracer ratio method

Introduction

Cattle represent a large proportion of Swiss livestock and account for 74% of ammonia (NH_3) emissions of livestock farming. Whereas so far, tie stalls for dairy cattle have prevailed, the trend is now toward loose housing with natural ventilation and outdoor exercise yards. Improvements in animal welfare are offset by a significant increase in the soiled areas, leading to comparatively higher NH_3 emissions.
There is thus a need for reliable emission inventories and implementable recommendations on emission reduction. The few published results vary considerably, are mostly based on short-term measurements and were mainly collected from housing with forced ventilation. The lack of emission data for natural ventilation and outdoor exercise yards is essentially due to difficulties in determining the air exchange rate.

Requirements and measuring concept using two tracer gases

To obtain reliable emission values for loose housing with natural ventilation and outdoor exercise yards, a measuring concept and a corresponding measuring arrangement are needed. They must be suitable for in situ monitoring on commercial farms and that meet the following requirements:
To take account of the climatic variation during the year in housing influenced by the out-door climate, measurements must be taken in summer, winter and the in-between seasons. Due to variations in emissions throughout the day due to climate, use and management activities, individual measurements should always cover a minimum period of 24 hours. Daily means suffice in order to derive emission factors. A higher time resolution is desirable in order to record daily patterns, relevant impacting factors or the effects of short-duration events. The air exchange rate in open housing can react very dynamically to external factors. In order to quantify emissions in such housing representatively, the fraction of time recorded at each sampling location must be as high as possible. A high spatial resolution is necessary to take into account the large housing areas and volumes, and the large air exchange surfaces with multiple apertures. As individual housing areas vary in terms of their emission potential and affect one another, allocation of emissions to housing areas is necessary with a view to reduction measures. To classify the emission values, parameters such as herd size, feeding ration, management, surface, climate and nutrient content of the manure must be documented. The background concentration of the measurement parameters must also be determined. A comparison of published results of emission measurements for similar housing systems showed a considerable

farm-to-farm variation. Taking measurements for a single housing system on several farms will at least reveal the farm effect.

To meet these requirements, a tracer ratio method was selected and improved for emission quantification from housing with natural ventilation and an outdoor exercise yard. The use of two tracer gases permits not only validation of the tracers but also allocation of the emissions to individual housing areas. NH_3 emissions are determined from the known mass flow of added tracers and the concentration ratio of the tracer gases to ammonia. This concept requires that the dosing of the tracers mimics the emission sources and that the tracers and NH3 disperse equally.
Gaseous tracers must have the following properties: (i) non-toxic to humans and animals, (ii) chemically inert, (iii) no surface adsorption, (iv) low, constant background concentrations, (v) sensitive, precise analysis and (vi) commercially available. In addition to the well established SF_6 tracer, trifluoromethyl sulphur pentafluoride (SF_5CF_3) was introduced as a second tracer. Atmospheric concentrations of SF_5CF_3 are very low (Sturges et al., 2000), and its properties are similar to SF_6. A procedure was designed to produce SF_5CF_3 tracer gas and to determine its concentration by FTIR. An existing GC-ECD method for SF_6 was improved to enable both tracers to be determined precisely, independently and sensitively in the same analytical process (Figure 1). The detection limit for both tracer gases is approximately 1 ppt.

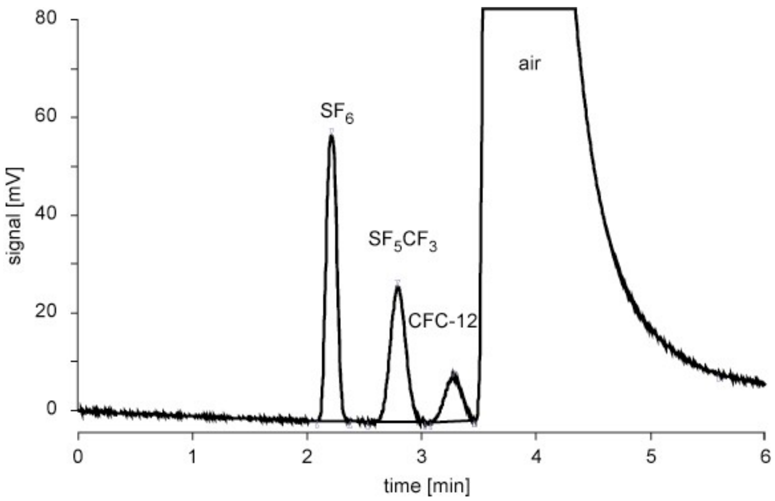

Figure 1: Chromatogram of SF_6 (approx. 108 ppt) and SF_5CF_3 (approx. 133 ppt); loop 2.4 ml.

The tracers are continuously dosed directly to the emitting surface in the housing through critical orifices. Sampling is carried out quasi-continuously covering the spatial distribution of the stall apertures.
Preliminary experiments were carried out in two dairy housing systems to test and improve the measurement concept and setup in situ. NH_3 was measured using a commercially available NH_3 trace gas analyser (TGA 310, Omnisens SA, Switzerland). This instrument operated reliably under shed conditions, and its time resolution, sensitivity and dynamic range was sufficient to follow the dynamics and daily patterns of NH_3.
Based on these preliminary experiments, the described measuring concept using two tracer gases will be used in cubicle housing systems with an outdoor exercise yard to improve the data basis for NH_3 emissions.

References

Sturges, W.T., T-J. Wallington, M.D. Hurley, K.P. Shine, K. Shira, A. Engel, D.E. Oram, S.A. Penkett, R. Mulvaney and C.A.M. Brenninkmeijer, 2000. A Potent Greenhouse Gas Identified in the Athmosphere: SF_5CF_3. Science 289, 611-613.