Search for ways to reduce ammonia and greenhouse gas emissions from dairy housing in Switzerland

Jernej Poteko[1,2], Angela Schwarm[2], Joachim Mohn[3], Kerstin Zeyer[3], Michael Kreuzer[2], Sabine Schrade[1]
[1] Agroscope, Institute for Sustainability Sciences ISS, Ettenhausen
[2] ETH Zurich, Institute of Agricultural Sciences, Zurich
[3] Empa, Laboratory for Air Pollution / Environmental Technology, Duebendorf

Contact person: jernej.poteko@agroscope.admin.ch

Introduction

Model calculations show that approximately 94% of the ammonia (NH_3) emissions in Switzerland in the year 2007 came from farming and around 34% of those originated from livestock housing (Achermann et al., 2009). About 80% of the methane (CH_4) emissions and 75% Nitrous oxide (N_2O) emissions in Switzerland are derived from agricultural activities (BLW, 2011), contributing significantly to the greenhouse footprint of this sector. According to the Agricultural Environmental Targets (BAFU and BLW, 2008), NH_3 emissions need to be reduced by approximately 40%. One goal of the Swiss "Agricultural Climate Strategy" is a reduction of at least one third in greenhouse emissions from Swiss agriculture by 2050 compared with 1990 (BLW, 2011; Wiedemar and Felder, 2011).

The aims of this large collaborative project are to develop structural/process engineering and nutritional abatement strategies to reduce NH_3 and CH_4 emissions and to quantify their reduction potential under Swiss dairy farming conditions. The project will be carried out in a new experimental housing for dairy cows of Agroscope ISS, Waldegg near Taenikon, as well as at the Teaching and Research Center Agrovet-Strickhof, Lindau-Eschikon.

Structural/process engineering abatement strategies

In the first project phase, the NH_3 reduction potential of introducing a solid floor with slope, urine-collecting gutter and scraper with urine-collecting gutter cleanser (Figure 1) will be quantified in comparison to the conventional reference system solid floor without slope and gutter. The slope shall ensure rapid urine drainage from the surface into the urine gutter and thus minimize urea hydrolysis to NH_3, which begins about 0.5 to 1 h after contact of the urine with the excrement or with the soiled area (Monteny, 2000). Because of that the drainage process has large importance for abatement of NH_3 formation. Experiments by Steiner et al. (2012) showed that a gradient of 3% is optimal for the drainage process at still sufficient cow comfort.

NH_3 emissions from exercise areas with a slope were studied in the 1990s in the Netherlands. A solid-concrete-floored exercise area with a transverse slope of 3% towards the centre and a central urine gutter showed a reduction in NH_3 emissions of around 50% in comparison with a slatted floor (Swierstra et al., 1995). Here, dung removal was carried out hourly. Braam et al. (1997a) conducted several experiments. Accordingly, the NH_3 emissions on a solid floor with a one-sided slope of 3% with urine gutter at the cubicles fell by around 20% in comparison with a concrete exercise area without a slope. With a transverse slope of 3% towards the centre and a central urine drain on solid floor (dung removal every 2 h), NH_3 emissions were reduced by around 50% in comparison with a perforated reference exercise area (Braam et al., 1997b). Two further urine drains showed no significant additional effect on the NH_3 emissions (Braam et al., 1997b). These studies can be applied to the Swiss housing systems only in principle, but since we are dealing here with closed housing with comparatively small exercise areas the level of reduction is likely different.

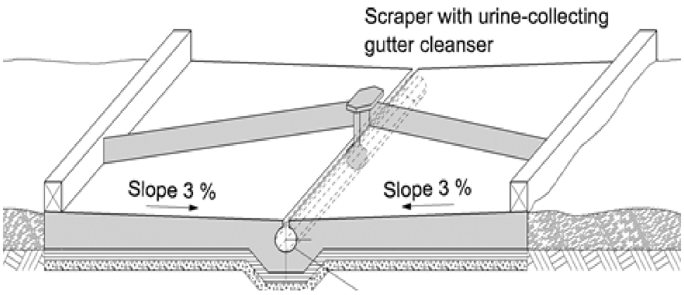

Figure 1: Schematic cross-section of solid concrete floor with slope, urine-collecting gutter and scraper with urine-collecting gutter cleanser (BAFU and BLW 2011).

In the second project phase, the NH_3 reduction potential of feeding stalls (Figure 2) will be quantified. Their use should result in a less-soiled area in the feeding aisle. The feeding area will be structured with feeding stalls with partitions. In the case of a raised standing surface with partitions, the animals are guided at the feeding place in such a way that very little excreta accumulate on the platform. In this way, the heavily soiled area might be reduced by up to 25% whilst the available space remains unchanged. A malleable floor can also improve the comfort of the animals in a functional area where much time is spent (Georg and Meyer, 2002), because animals are not disturbed during feeding by the scraper and dung removal can be performed at more frequent intervals thus further reducing the emission potential.

Both, solid floor with slope, urine-collecting gutter and scraper with urine-collecting gutter cleanser as well as elevated feeding stalls with partitions should also provide drier conditions for the cows' claws, which should promote claw health.

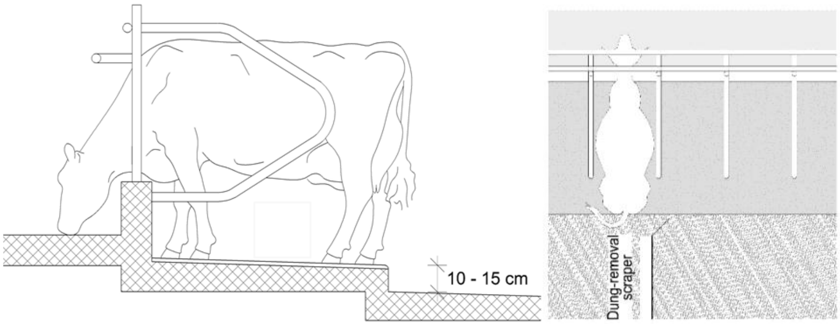

Figure 2: Schematic cross-section and top view of elevated feeding stalls with partitions (BAFU and BLW 2011).

Nutritional abatement strategy

The enteric fermentation of ruminants and fermentation from manure are sources of CH_4 emissions from livestock (Monteny et al., 2001). As it has never been tested before in entire dairy housing, the recovery of the effect of supplementing the diet of an experimental herd with a known anti-methanogenic natural feed component, extruded linseed (given in an amount providing 3.5% lipids in dry matter), will be studied. Dairy cow diets of experimental as well as reference herd will be based on staple feed production under Swiss farming conditions (grass silage, maize silage, hay and a pelleted concentrate).

Determination of the abatement potential

A new specifically designed experimental dairy housing at Waldegg near Agroscope ISS in Taenikon provides the opportunity for the progressive development and testing of NH_3 and greenhouse gas reduction strategies on herd level in practical scale. To quantify emissions at housing conditions with natural ventilation a tracer-ratio method with two tracer gases (SF_6 and SF_5CF_3) developed by Agroscope ISS and Empa (Schrade et al. 2012) will be applied. Thereby the NH_3 emissions as well as the sum of enteric and manure-derived CH_4 emissions will be measured in the experimental dairy housing for comparative quantification of reduction potential of the abatement strategies. In the case of the nutritional strategy CH_4 and N_2O data obtained in the experimental dairy housing will be validated on individual cows in respiratory chambers and lab-scale measurements of manure-derived emissions.

Outlook

Emission measurements in the experimental dairy housing will start in summer 2015. The study is carried out in an interdisciplinary collaboration between Agroscope ISS, ETH and Empa. The implementation of these abatement strategies into farming practice are intended to support achieving the political goals of reducing NH_3 and greenhouse gas emissions.

The study described here is funded by the Swiss National Research Program (NRP 69; 145144) and the Federal Office for the Environment (FOEN).

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