SOLID FLOORS WITH A SLOPE FOR RAPID URINE DRAINAGE: FIRST RESULTS FROM AMMONIA EMISSION MEASUREMENTS IN WINTER

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ABSTRACT: Rapid urine drainage from floor surfaces leads to a reduction in ammonia (NH_3) formation and release. This can be achieved in dairy housing by a combination of a solid floor with slope, a urine-collecting gutter and a special scraper with dung removal at frequent intervals. Emissions were measured on a practical scale in experimental dairy housing at Agroscope, Tänikon (Switzerland). The two spatially separated housing compartments allow comparable measurement conditions (e.g. climate). To determine emissions under natural ventilation, a dual tracer-ratio method with the two tracer gases sulfur hexafluoride (SF_6) and trifluoromethyl sulfur pentafluoride (SF_5CF_3) was used. Measurements over three seasons covered climatic variations throughout the year. First results of a four-day measuring period in winter 2015 show an NH_3 emission reduction of around 20% in the compartment with solid floors with slope and urine-collecting gutter compared to the reference with solid floors without a slope. Lower NH_3 emissions in the reduction variant were attributed to reduced amounts of urine on the floor surface with slope in comparison to the reference. Concerning live weight, food consumption, milk yield and milk urea content, there were only slight differences between the two herds. In addition, climatic conditions in both compartments were comparable with air temperatures from -2 to 12 °C.

Keywords: NH_3, dairy cattle, natural ventilation, tracer-ratio method, mitigation strategy

INTRODUCTION: Monteny (2000), Snoek et al. (2014) and Keck (1997) showed in model calculations and/or in studies on a pilot-plant scale that the presence and amount of urine on the surface of the exercise area significantly influences NH_3 emissions. Less soiling of the surface as well as rapid urine drainage from the urease-active exercise area to the covered slurry storage is therefore important. In the Netherlands in the 1990s, NH_3 emissions of solid floors with a slope and one or more urine-collecting gutters were investigated in a single-row cubicle housing system for dairy cattle. With a 20 to 50% reduction in NH_3, solid floors with a 3% transverse slope and a different number or positioning of urine-collecting gutters exhibited a significant effect compared to the reference variants of solid floor without slope (Braam et al. 1997a; Braam et al. 1997b; Swierstra and Braam 1995). Results of these studies are only partially applicable to Swiss housing systems, because they were determined on closed housings with forced ventilation and comparatively small floor areas.
The aim of this study was to quantify the NH_3 emission reduction of solid floors with slope (3%) and urine-collecting gutter in comparison to solid floors without slope under Swiss dairy housing conditions.

1. MATERIAL AND METHODS: Emission measurements on a practical scale were conducted in a new experimental housing built at Agroscope, Tänikon (Switzerland). The housing consists of two experimental compartments – each for 20 dairy cows – and a central section for milking, technical installations, office and analytics (Fig. 1) (Schrade et al. 2016). The two spatially separated housing compartments provide comparable measurement conditions (e.g. climatic conditions) on a practical scale. The emission reduction potential of abatement measures can thereby be quantified in relation to a reference variant.

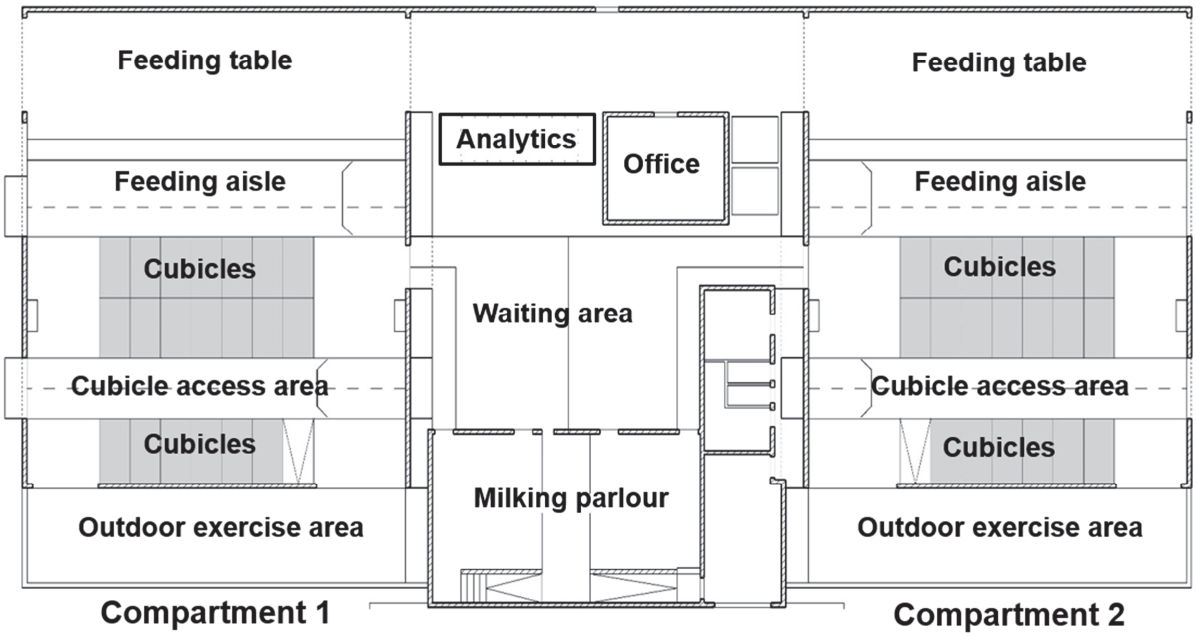

Figure 1: Schematic top view of the experimental dairy housing for emission measurements in Tänikon with two compartments (reduction and reference variant).

A dual tracer-ratio method employing two tracer gases SF_6 and SF_5CF_3 (Schrade et al. 2012) is used to determine emissions from the naturally ventilated housing. The diluted tracer gases (ppm-range) are dosed continuously through steel tubes with critical capillaries next to the aisles to mimic the emission sources. Integrative air samples are collected at a height of 2.5 m with a piping system consisting of teflon tubes and critical glass capillaries. The analytical instrumentation for NH_3 (CRDS, Picarro Inc., Santa Clara, CA, USA) and tracer gas analysis (GC-ECD, Agilent, Santa Clara, CA, USA) is located in an air-conditioned trailer in the central section of the housing. Besides NH_3 emissions, relevant meteorological parameters in the housing and the outside area, animal parameters (e.g. live weight, milk yield, milk composition, milk urea content, urine urea content), feed (quality and quantity, amount of trough residue), exercise area soiling (type, amount, composition), and ethological aspects (e.g. slipping events) are recorded. Measurements started in August 2015 and were conducted over three seasons covering climatic variations in the course of the year.

2. RESULTS AND DISCUSSION: This paper presents initial results of a four-day measuring period in winter 2015. During these four days, cows had no access to the outdoor exercise area. In both compartments, dung removal was conducted 12 times per day by an automatic scraper. As usually done during winter, curtains were completely closed. The average live weight of the individual cows was nearly the same (around 690 ±80 kg) in both herds. Concerning feed intake, milk yield and milk urea content, there were only slight differences between the two herds. Air temperature in both compartments followed the same temporal trend and ranged from -2 to 12 °C. NH_3 emissions exhibited clear daily patterns (Figure 1). NH_3 emissions of the reduction variant seemed to be lower than those of the reference variant. First emission calculations showed a reduction in NH_3 emissions of around 20% in the compartment with solid floors with 3% slope and urine-collecting gutter compared to the reference without slope. These results confirm the NH_3-reducing effect of rapid urine drainage from flooring with a transverse slope that was observed in studies in the Netherlands in the 1990s (Braam et al. 1997a; Braam et al. 1997b; Swierstra and Braam 1995).

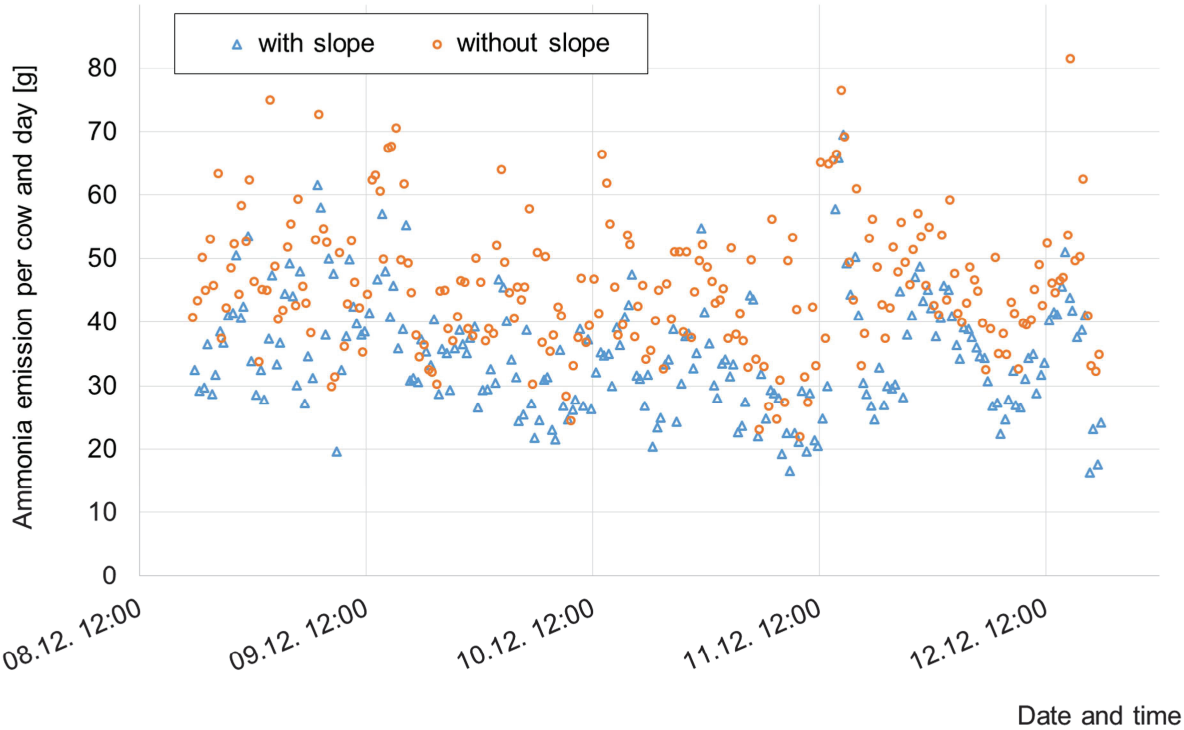

Figure 2: Comparison of NH_3 emissions for solid floors with 3% slope vs. solid floors without slope in winter 2015.

The amount of urine on the floor surface in the reduction variant with slope was also clearly reduced in comparison to the reference without slope (Figure 3).

Figure 3: Exercise area soiling in the compartment with 3% slope (left) and the reference without slope (right).

3. CONCLUSION: Rapid urine drainage from solid floors seems to reduce NH_3 emissionsMeasurements conducted in experimental housing over four consecutive days in winter 2015 display an NH_3 emission reduction of around 20% for solid floors with a 3% slope and urine-collecting gutter compared to the reference variant without a slope. The measurements in both housing compartments were conducted simultaneously and hence under comparable climatic conditions. The tracer-ratio method using two different tracer gases SF_6 and SF_5CF_3, the dosing and sampling design, and the analytical setup demonstrated its capability for comparative emission measurements. The average NH_3 mitigation potential will be evaluated including results from summer and autumn measurement periods. Results will be interpreted with respect to additional parameters (e.g. meteorological data, exercise areas' soiling, animal data) and using statistical analysis. In addition, evaluation of the other measurement periods and parameters may yield information on the relationships between NH_3 and CH_4 and/or CO_2 emissions.

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