# Emissions of compost bedded pack barn for cattle

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## Abstract

The compost dairy bedded pack barn is an animal-friendly housing system for cattle. It consists of a large, open resting area, usually bedded with sawdust. The most critical success factor for managing a compost dairy bedded pack barn (CDB) is providing a comfortable, dry resting surface for cows at all times.

Within the project "Assessment of compost dairy bedded pack barns with regard of compost quality, odour and ammonia emissions" emission measurements ($NH_3$) of 23 CDB were executed during three different seasons (summer – autumn – winter). Samples for the analysis of odour-active volatile organic compounds (VOCs) and chemical parameters (e.g. pH value, dry matter, C/N ratio) were taken. In addition, an extensive microbiological screening with special attention to harmful bacteria was carried out. The samples were picked from the compost manure mattress. In CDB, mainly sawdust is used as bedding material despite its increasing cost.

Concerning the assessment of emissions in CDB no correlations between ammonia and odour-active VOCs could be determined, but the majority of the analysed CDBs shows emission concentrations below or in the range of cubicle housing systems.

## Introduction

The compost dairy bedded pack barn (CDB) is a new and an animal-friendly housing system for cattle, which is also positively assessed from the perspective of claw health [1, 2]. The most critical success factor for managing a CDB is providing a comfortable, dry resting surface for cows at all times [3]. A CDB consists of a large, open resting area usually bedded with sawdust. Due to its good absorptivity, structural stability and good decomposition under aerobic conditions, sawdust is a very well-suited bedding material. The major drawback of sawdust is the constantly increasing costs, which makes the use of cheaper alternatives like spelt husk, wood chips or hay from nature conservation areas more attractive.

However, until now only scattered investigations about ammonia and odour-active volatile organic compounds (VOCs ) were carried out [4–6]. Knowledge about VOC emission of CBDs is of utmost importance, as potentially odorous emissions will not only effect the animals' well-being. Emission of malodourous compounds would also lead to complaints by neighbouring residents.

Another important parameter in a CDB is the large diversity of microorganisms [7]. In Friesland (The Netherlands), for instance, the group of extremely thermophilic aerobic spore-formers (XTAS) was the reason for a ban on the delivery of milk from composting plants to dairies [8]. Because of this ban, intense investigations and characterization of the compost mattress especially with respect to the microbial load is of increasing importance. Nevertheless, a total screening and characterization of the different

*B. Siegmund & E. Leitner (Eds): Flavour Sci.*, 2018, Verlag der Technischen Universität Graz
DOI: 10.3217/978-3-85125-593-5-87, 

microorganisms in the compost mattress (e.g. harmful bacteria, like *Klebsiella spp*.) has not yet been conducted.

## Experimental

### *Sampling*

Within this project, emission measurements ($NH_3$) of 23 CDB were performed and samples for the analysis of odour-active VOCs and chemical parameters were taken. The samples were drawn from the compost manure mattress during three different seasons (summer – autumn – winter) and on six different locations of the mattress.

### *Analysis of volatile compounds*

The gaseous $NH_3$ emissions were measured by an open dynamic chamber and analysed by a Multigasmonitor INNOVA 1412. For the analysis of potentially odorous compounds, headspace solid phase micro extraction was carried out prior to GC analysis to enrich the VOCs from the mattress samples (50/30 µm DVB/Carboxen/PDMS 2 cm stable flex fibre, Supelco; enrichment at 40°C for 20 minutes). Gas chromatography mass spectrometry (Agilent 7890A GC Systems and Agilent 5975C VL MSP, electron impact ionisation, 70eV, scan mode) equipped with a nonpolar analytical column (HP5MS, 30m x 250µm x 1µm) was used for the analysis of the VOCs. Quantitation was performed using deuterated dodecane as internal standard. Identification of the compounds was based on the comparison of the obtained mass spectra with mass spectra from MS databases or literature and the linear temperature programmed retention indices and comparison to data from authentic reference compounds and data from literature.

### *Microbial screening*

To receive information about the microbial load of CBD compost mattresses, an extensive microbial screening was carried out. Special attention was paid to the characterization of harmful bacteria, like *Klebsiella ssp*. and XTAS (extreme thermophilic aerobic spore-formers). To determine the bacterial count (colony forming units, CFU) samples were plated on plate-count agar (PCA) and on selective culture media (e.g. Baird Parker RPF Agar or SGC2).

## Results and discussion

Results from the CDB study show, that ammonia emissions are generally lower from CBD than in cubicle housing systems (Figure 1), except for the use of spelt husk and CBD with reduced lying area availability per cow. Concerning the assessment of emissions in CDB, no correlations between ammonia and odour-active VOCs formation were found.

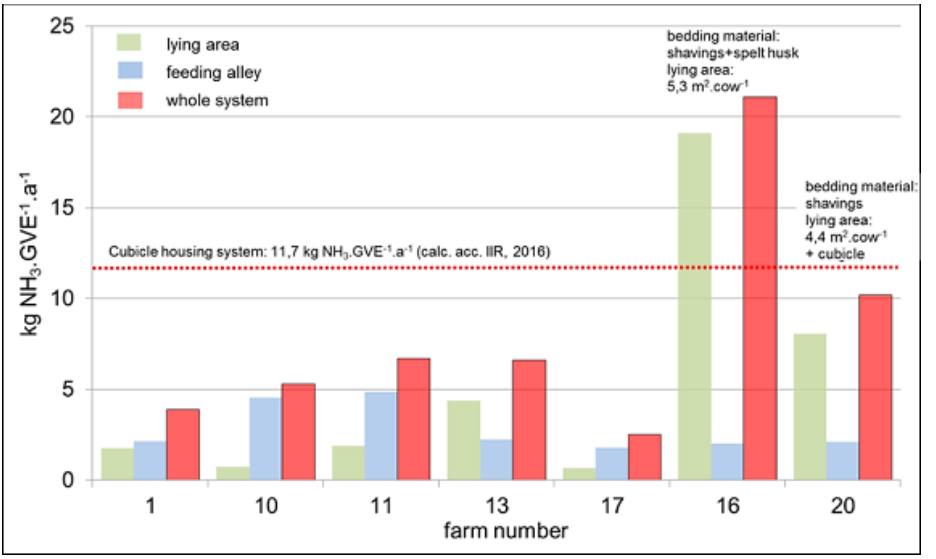


**Figure 1:** Ammonia emissions in CDB summer and autumn 2015 in comparison to a cubicle housing system

Concerning the potentially odour-active VOCs, the same conclusion was drawn as for ammonia emissions. The VOCs have a high dependency regarding seasonal changes and on the bedding material (Figure 2). Especially phenolic and sulphur compounds (e.g. dimethyl disulphide) as well as aldehydes and terpenes (e.g. 3-methylbutanal, camphene, α- and β-pinene) were identified as the major compounds responsible for the odour of the compost manure mattress. Phenols and sulphur substances show constant concentrations, whereas aldehydes and terpenes range from low to high concentrations depending on the bedding material or on the composting state of the resting surface. Furthermore, in summer, the total odour-active VOCs are - as expected – significantly higher than in winter, which shows that the annual temperature fluctuations are one of the major external factors of influence on odour formation of the CDB. VOC measurements in a comparable cubicle housing system showed 10 to 100 times higher VOC values than in CDB (depending on the compound).

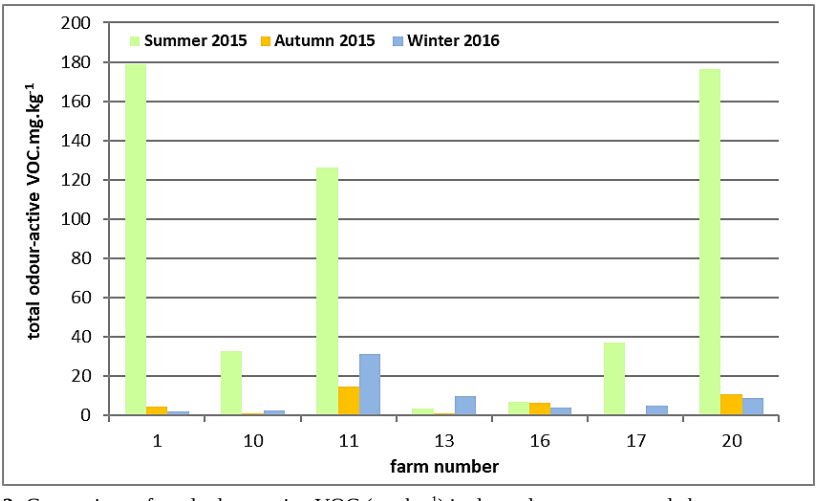


**Figure 2:** Comparison of total odour-active VOC (mg $kg^{-1}$) in dependency to seasonal changes

Microbial analysis of the compost mattresses showed no significant variation neither depending on the individual season nor on the farm (Figure 3). In general, farms using spelt husk showed the highest bacterial counts, whereas the lowest microbial concentrations were found for bedding with sawdust. Extreme thermophilic spore-formers (XTAS) were analysed in a very low concentration range. So far, no limit value exists for the presence of XTAS. Based on the results obtained from the 23 investigated CDBs, it can be assumed that CDBs do not present any hazard potential.

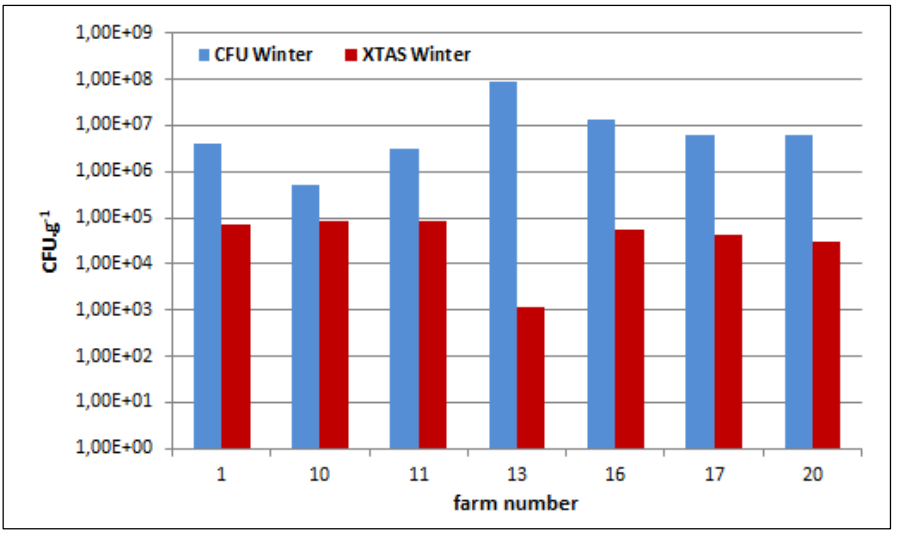


**Figure 3:** Microbiological Screening (total count vs. XTAS count) winter 2015/16

The results of this study show that a well-managed CDB is not only animal-friendly but it is also a farming option with less emissions compared to a commercial used cubicle housing system. Consequently, CDBs are said to be a very recommendable and suitable cattle farming option.

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