AIRBORNE ENDOTOXINS IN GERMAN LIVESTOCK BUILDINGS - FROM OCCUPATIONAL BURDENS TO A REGIONAL EMISSION INVENTORY

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Introduction

Livestock operations are of increasing public concern, because these facilities host significant loads of airborne gases and particulate matter. Within the particulate matter biologically potent endotoxins are of interest, because inhaled endotoxins are capable to induce initially inflammatory effects in the respiratory tract. As consequence, endotoxins are able to contribute to acute (organic dust toxic syndrome, ODTS) and chronic occupational complaints (chronic obstructive pulmonal disease, COPD).

Like all other airborne pollutants endotoxins are transported into the environment via the ventilation system. Keeping the potential endotoxin-related complaints in mind, the knowledge about emitted amounts of endotoxins into the environment is highly desirable to look for potential threatening effects in residents caused by endotoxins, because clean air and therefore public health may be relevant for authorities and decision makers in order to turn the threat away.

The aim of the paper is to give an overview of German livestock-related airborne endotoxin concentration, their relationship to proposed occupational exposure limits and to present exemplarily an emission inventory of endotoxins for Lower Saxony, Germany.

Material and methods

An air quality survey was carried out in 81 German commercially operated livestock buildings (33 cattle, 32 pig and 16 chicken production facilities). Multi-point dust sampling was carried out by the filtration method to obtain material for the final determination of inhalable endotoxins via the Limulus-Amebocyte-Lysate (LAL) gelation test. The results were expressed as nanograms (ng) per m^3. In each of the animal houses every measuring cycle comprised a 24-hour period, which was normally divided into two 12-hour sampling periods of day and night, but the presented concentrations here are related to daytime only (for details see Phillips et al. 1998, Seedorf et al. 1998).

For the emission inventory emission factors were firstly estimated by multiplying the 24 hour, i.e. daily mean concentrations of endotoxins and the daily mean ventilation rate (m³/h), which was determined with the aid of the CO_2 balance method. Finally, a district-based emission inventory was established for Lower Saxony using the emissions factors, specific production data (e.g. pasture time) and data derived from the agricultural census in 1999 (Seedorf 2004).

Results and discussion

On the basis of toxicological data and experiences from field studies, proposals have been made for maximum acceptable exposure limits (EL) to protect human health during activities in livestock buildings. In most cases so called no-observed-effects-levels (NOEL; EL: 4.5, 9, 33 ng/m³) were used to define still tolerable exposure concentrations and their excess may provoke reduced forced expiratory volumes in one second (FEV_1, EL: 50 ng/m³), airway inflammations (EL: 10 ng/m³), general symptoms (e.g. fever, EL: 100 ng/m³) and/or toxic pneumonitis (EL: 200 ng/m³). Due to the biological variability of the endotoxin composition, the confounding effects of other active agents (cross-interferences) and the susceptibility of the exposed person the derived threshold limit values can be highly variable. However, the median endotoxin concentration of 178.1 ng/m³ in broiler houses exceed all above selected exposure limits between 4.5 and 200 ng/m³, while calf houses and piggeries only meet the lowest level of 4.5 ng/m³. Beefs, sows, weaners and laying hens caused airborne concentrations between 12.1 and 16.2 ng/m³ and give concern for airway inflammation. Relative marginal endotoxin yields were found in livestocks with dairy cows, leading to the assumption that endotoxins do not cause a considerable health problem for the respiratory tract.

Table 1. Median and peak concentrations of airborne inhalable endotoxins in different types of livestock production systems during daytime and exceeded exposure limits (X) in relation to the median values

	Dairy cows	Beefs	Calves	Sows	Weaners	Fattening pigs	Laying hens	Broilers
Median conc.	4.0	12.1	6.5	15.5	16.2	4.9	13.9	178.1
Livestock #	7	10	16	16	8	8	8	8
Exceeded EL ng/m³								
4.5)1		X	X	X	X	X	X	X
9)2		X		X	X		X	X
10)1		X		X	X		X	X
33)3								X
50)2								X
100)1								X
200)1								

conc.: concentration **)1: reviewed by Rylander (2002)**
EL: exposure limit **)2: Castellan et al. (1987): NOEL (9 ng/m³); significant decrease in FEV_1 (50 ng/m³)**
)3: Rylander et al. (1985): NOEL

Apart of the indoor health concerns environmental health aspects might be also relevant. Therefore, an emission inventory was exemplarily calculated for Lower Saxony, Germany (Fig.1). It is obvious that three areas can be principally defined with markedly different endotoxin loads per year and square kilometres (g/a.km²). The eastern and southern part of Lower Saxony showed only relative small amounts between 0.1 and 1.0 g/a.km² while the districts in the North and close to the North Sea coastline were already exposed to loads in the range between 1.0 and 3.0 g/a.km². But the highest endotoxin burdens were calculated in the Western and South Western part of Lower Saxony, where loads of more than 3.0 g/a.km² occurred, which is indicative for the relative high animal density of pigs and poultry in this area (Seedorf 2004).

Conclusions

1. Based on daytime measurements different livestock types cause considerable different airborne endotoxin burdens, which are in the range from 4 to 178 ng/m³.
2. Due to varying endotoxin levels all investigated livestock types exceed the lowest proposed exposure limit for humans with the exception of dairy cow houses.
3. For a holistic approach released emission loads might be also of environmental concern. Therefore, emission inventory may help in future to assess the environmental risk of endotoxins when its outdoor impact can be estimated much better than yet.

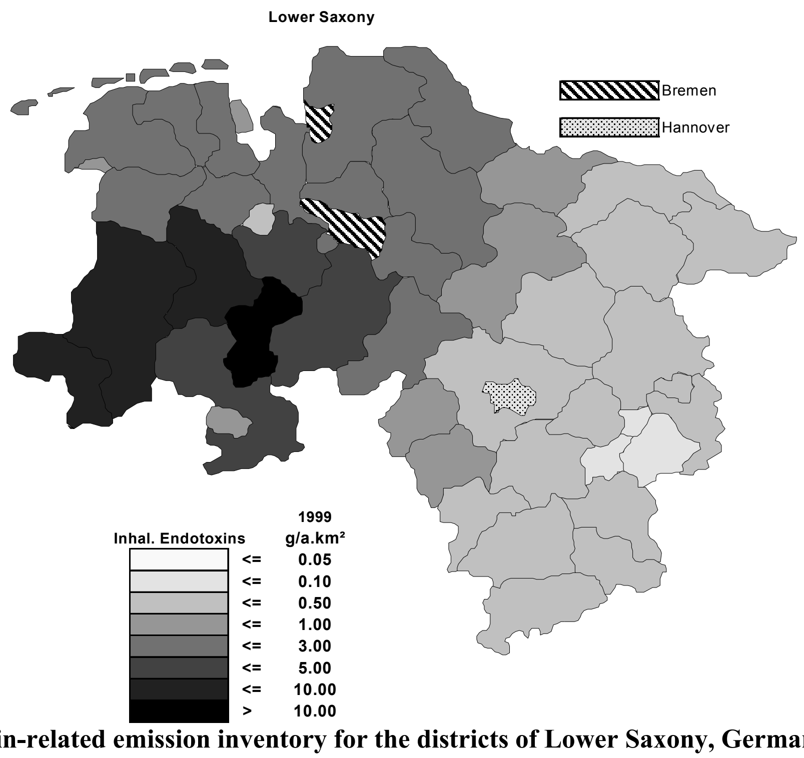

Fig. 1: Endotoxin-related emission inventory for the districts of Lower Saxony, Germany, in 1999.

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