SIZE DISTRIBUTION OF AIRBORNE PARTICLES IN ANIMAL HOUSES

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SUMMARY

The objective of this study was to determine concentration and size distribution of airborne particles inside and outside animal houses for broilers, broiler breeder (with bedding); layers (floor or aviary housing system); turkeys (with bedding), pigs: fatteners (traditional house, low emission houses (dry feed, or wet feed), piglets, sows (individual or group housing); cattle (cubicle house), and mink (cages). Dust concentrations, both in counts and mass, in the different particle size ranges were highest in poultry houses. The concentrations in pig houses were higher than those in cattle and mink houses. The count particle size ranges < 1.0 µm was highest with average of 95%, while mass particle was highest in size ranges > 2.5 µm (on average 95%). Most count particles outside were in the size range < 1.0 µm (99%).
Keywords: Particle size distribution, animal houses, dust concentration

INTRODUCTION

In animal houses, especially those for pigs and poultry, air quality can be seriously impaired by high dust concentrations (Wathes, Holden et al. 1997; Takai, Pedersen et al. 1998). These cause health problems for humans working in this environment (Donham, Reynolds et al. 1995; Herr, Bittighofer et al. 1999; Pope, Burnett et al. 2002; Andersen, Von Essen et al. 2004), and probably also for the animals living in these houses (Al Homidan and Robertson 2003). Also, airborne particles from inside the animal houses can escape the building via exhausted air and contribute to particle concentrations in the ambient air (Takai, Pedersen et al. 1998; Seedorf and Hartung 2000). One of the most important characteristics of dust is its size and its related size distribution, because this influences the behaviour and transport of the particles in the air and the choice of control technology (Zhang 2004). Particle size determines the impact of dust on human and animal health, as well (Mercer 1978). Particles size PM10, PM2.5, and PM1 are mainly responsible for health problems because they can travel into the respiratory system (Collins and Algers. 1986). The smaller the particles are, the deeper they can penetrate into the respiratory system and the greater their impact is on animal and human health.

Despite of many efforts, knowledge on particle size distribution (PSD) is still limited, for example particle size distributions in a wide range of animal houses and categories. The objective of this study was therefore to determine the particle size distribution, counts and mass, in different commercial animal houses in the Netherlands.

MATERIAL AND METHODS

Animal houses

PM10 mass and PSD were determined in houses of 13 different combinations of animal species/housing types, located in the Netherlands. Each species/housing combination was measured at two farms (replicates) at two time points in spring and summer 2009. The following animal species/housing combinations were studied: broilers, layers housed in floor system (layer_floor), layers in aviary system (layer_aviary), broiler breeders, turkeys, piglets, fattening pigs in traditional houses (fat_pig_trad), fattening pigs in modern low-emission housing with dry feed (fat_pig_mod_dry), fattening pigs in modern low-emission housing with wet feed (fat_pig_mod_wet), sows in individual housing (sow_individual), sows in group housing (sow_group)), dairy cattle (cattle), and mink.

Dust sampling

PM10 mass concentrations and PSD in counts were both measured using aerosol spectrometers based on the light-scattering principle. PM10 mass concentrations were measured with a DustTrak monitor (TSI inc., 500 Cardigan road Shoreview, MN 55126-3996, USA) **,** whereas PSD in counts was measured with a Grimm instrument model number 1.109 (Grimm Aerosol Technik GmbH & Co., Ainring, Germany)

RESULTS

PM10 mass concentration

PM10 mass concentrations were highest in layer_floor (3.78 mg m^{-3}) followed by layer_aviary (2.81 mg m^{-3}), turkey (1.87 mg m^{-3}), broiler (1.42 mg m^{-3}), piglet (1.15 mg m^{-3}), broiler_breeder (0.89 mg m^{-3}), fat_pig_trad (0.87 mg m^{-3}), fat_pig_mod_dry (0.65 mg m^{-3}), fat_pig_mod_wet (0.47 mg m^{-3}), sow_group (0.30 mg m^{-3}), sow_individual (0.18 mg m^{-3}), mink (0.07 mg m^{-3}) and cattle (0.07 mg m^{-3}).

Particle size and size distribution

Most particles inside the animal houses were found in the size ranges smaller than 1 µm: on average, 87.0% of total number of particles; 5.5% were in the size range 1 – 2.5 µm; 7.3% in the size range 2.5 – 10 µm and 0.24% in the size range 10 – 32 µm. In the outside air, 99.2% of the particles were smaller than 1.0 µm; 0.7% was in the size range 1.0 – 2.5 µm; 0.1% in the size ranges 2.5 – 10 µm and 0.005% in the size range 10 – 32 µm.

Figure 2 shows the standardized number fraction of particles in poultry, pig, cattle, and mink houses. The standardized number fraction for outdoor particles is given in each sub-figure, for comparison. For all animal house categories and also for outside samples, the highest fraction of particles was in the size range 0.25 – 0.30 µm. Number fractions decreased sharply with increasing particle size. For pig and poultry houses, two small peaks were observed: one between 0.65 to 0.70 µm, and one between 2.5 to 3.7 µm. It is obvious from Figure 2 that within the animal houses, especially those for poultry and pigs, the number fractions of the larger particles were much higher than outside.

Mass distribution

Particle size distribution in mass is dominated by particles in the size range > 2.5 µm. On average, 0.5% of particle mass was smaller than 1.0 µm, 2.0% of particle mass was in the size range 1 – 2.5 µm, 50.3% of particle mass in the size range 2.5 – 10 µm, and 47.3% of particle mass was in the size range 10 – 32 µm. For outside air, 11.0% of particle mass was smaller than 1.0 µm, 5.9% of particle mass was in the size range 1.0 – 2.5 µm, 17.1% of particle mass was in the size range 2.5 – 10 µm, and 66.0% of particle mass was in the size range 10 – 32 µm.

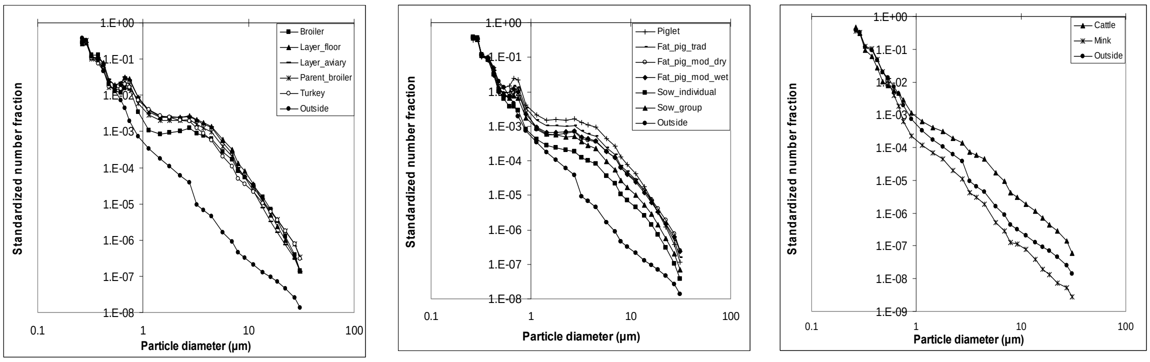

Figure 1. Standardized number fraction (at log-scale) of particles in the different size ranges (at log-scale) in 5 species/housing combination for poultry (left), 6 for pigs (middle) and 1 cattle house and 1 mink house.

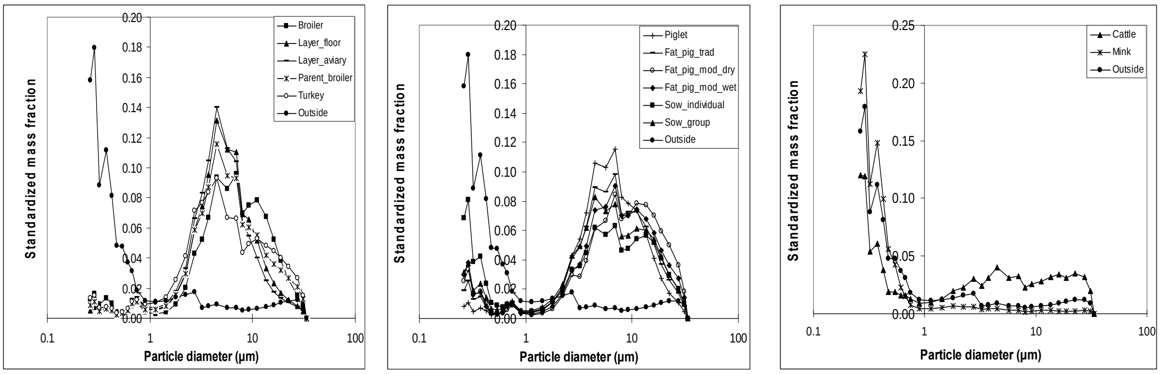

Figure 2. Standardized mass fraction of particles in the different size ranges (at log-scale) in 5 species/housing combinations for poultry (left), 6 for pigs (middle) and 1 cattle house and 1 mink house.

DISCUSSION

The high PM10 concentrations in poultry houses were most probably related to the presence and use of bedding by the hens for scratching and dust-bathing. The litter contains the main dust sources i.e. manure and feathers (Cambra-Lopez, Torres et al. 2010). In layer houses with battery cages a lot lower dust concentrations were reported (Takai et al., 1998). The low dust concentrations in cattle and mink houses are probably the result of a low dust production in combination with a high ventilation rate in the open naturally ventilated buildings. The number of particles smaller than 1.0 µm in pigs, cattle and mink houses did not differ much from the number of particles in this size range measured outside. This corroborates the hypothesis that the small particles in animal houses mainly come from outside (Zhang, Tanaka et al. 1998).
High variations in particle concentrations occurred not only between animal species/housing combinations, but also between farms within the same category, as shown by the relatively high standard error of means (Figure 2). This is in agreement with the findings of Martin et al. (1996) who also reported high variations in dust particle concentrations between animal houses. This is caused by the fact that each animal farm has its own control and managing practices and its own details in housing design, for the variations within farms of the same category in that study(Martin, Zhang et al. 1996) was the fact that farms were not sampled on the same day and at the same moment in the production cycle (Martin, Zhang et al. 1996).
The standardized mass distribution for the different animal species/housing combinations is contrary to the standardized count distribution. The standardized mass distribution of particles inside had a very different pattern than the pattern outside. Because of the relatively high numbers of small particles and very few big particles outside, the contribution of the small particles to mass was relatively large, while the mass of inside particles was dominated by the bigger particles. The standardized mass distributions of particles inside cattle and mink houses were very similar to those outside. As mentioned earlier, a possible explanation is the low particle production inside these houses and the high ventilation rate in these open naturally ventilated buildings.

CONCLUSIONS

- In terms of counts and mass, the dust concentrations in the different particle size ranges are generally higher in poultry houses than in pig houses, and are generally higher in pig houses than in cattle houses and mink houses.
- Particle counts in mink and cattle houses are more or less similar to the particle counts in outside air for all particle size ranges.
- Particle counts in animal houses are highest in the size range < 1.0 µm (87%), while particle mass is highest in size ranges > 2.5 µm (95%). Most particles outside are in the size range < 1.0 µm (99% in counts).

REFERENCES

For the reference list contact the corresponding author.