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Resuspension of dust from livestock buildings

Inhalable and respirable dust from livestock buildings are continually in the focus of discussion. To give more accurate prognosis for a simulation model, on the one hand the determination of emission factors has a great significance. Furthermore the transmission parameter should be included likewise in such calculations. In this project the transmission parameter sedimentation, adsorption and resuspension are determined for different livestock buildings in different lab tech benches. The resuspension and adsorption for airborne dust from livestock buildings is determined in a specific wind tunnel.

Keywords
Transmission parameter, resuspension, wind tunnel

Abstract
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In the surroundings of agricultural barn complexes especially the dust emitted by those barns sediments. Via resuspension, earlier deposited dust on a surface, can find its way back to the air flow. After a particle deposited onto a surface, the forces affecting the particle govern if it is removed from the surface. In this project the propability of reentering the air flow is to be determined for different particle size fractions. A dependance on both wind velocity and source of dust is assumed.

Resuspension of particles

Due to adhesion particles are either bound to a surface or to each other. This can be caused both by physics and chemistry. Especially small particles are highly affected by adhesion.

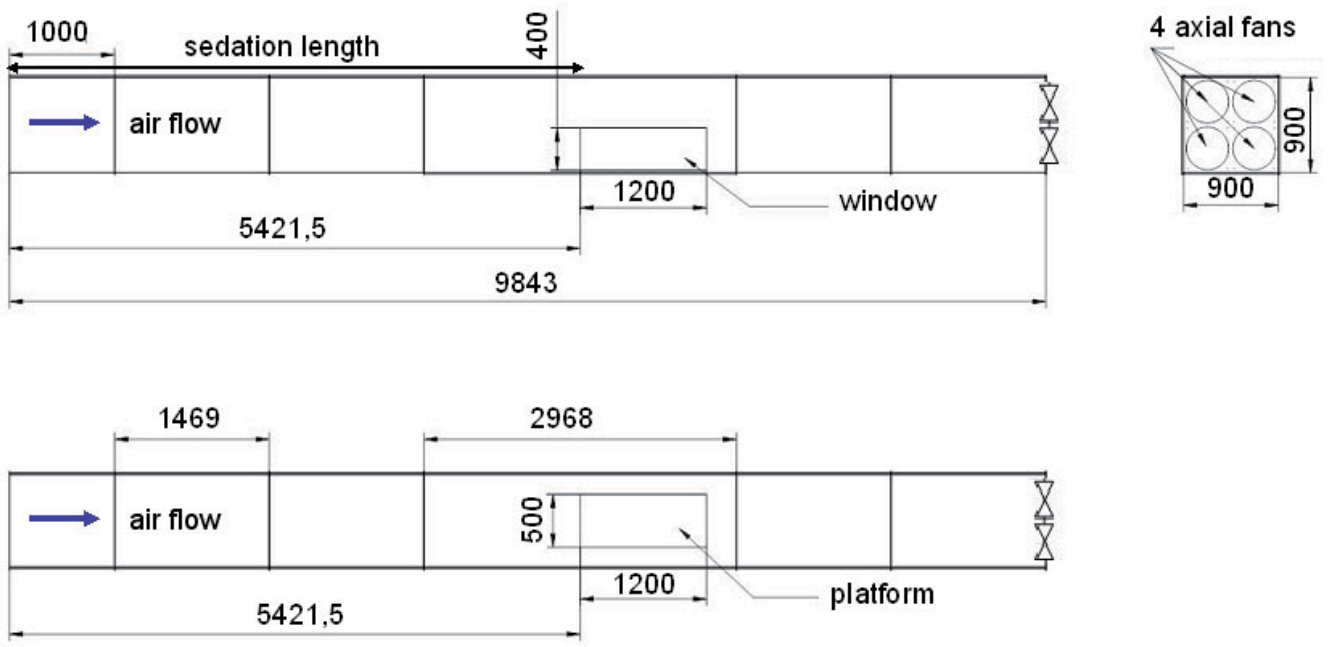
Particles are transported by fluid flow. This transport is affected by different phenomenas such as thermophoresis, diffusional phoresis and electrophoresis. Three different ways of transport may be differentiated, depending on particle size, surface roughness and potential barriers [1].

- Suspension is found if particles (< 70 µm) resuspend due to fluid flow. One distinguishes short time suspension for particles between 20-70 µm and long time suspension for particles smaller 20 µm
- Saltation affects heavier particles with a size between 60 and 1000 µm that are to heavy to enter the fluid flow. If they anyhow enter the flow, they sediment fast and move forward saltationally. The transition from saltation to suspension is called modified saltation (70-100 µm).
- Particles with a diameter of more than 500 µm cannot resuspend, this case is called reptation. However these particles creep along the surface, due to the kinetic energy of jumping particles.

Principle of measurement and experimental setup

The transmission parameter resuspension was measured in a wind tunnel with a square cross section of

Fig. 1



Side-view (top), cross-section (top right) and top view (bottom) of the wind tunnel

0.9 m width and a length of about 9.8 m (**figure 1**).

The implementation of a platform (0.5 m x 1.2 m) following the sedation length allows to incorporate different surfaces. This platform, that consisted of a chipboard in the first setup, carries the measuring technology that consists of two optical particle counters (OPC) (Model 1.108) by Grimm Aerosol Technik GmbH & Co. KG as well as a temperature and air moisture sensor and two vane anemometers by Ahlborn Mess- und Regelungstechnik GmbH. Data is collected online and displayed graphically.

Two intake positions are provided on the platform. The first OPC measures the particle number concentration in the front part of the platform and therefore distributes the background concentration. The second OPC is situated in the back part of the platform, behind the investigated surface and the settled dust. The OPC transfer their data every second, which results into a high time resolution. The particle number concentration is divided into eight size fractions according to optical equivalent diameter.

Following VDI 3783 two vane anemometers are installed diagonally on the platform and measure wind velocity before and behind the emitted dust sample. The temperature and humidity sensor records the climatic conditions.

The installation of four axial fans (Ø 0.3 m) by Firma Ziehl-Abegg allows to regulate the air velocity. The measurement routine is running automatically by a programme written with LabView 8.5.

Dust samples were taken from poultry, pig and dairy cattle barns. The dust samples are emitted on an area of 50 cm² and in a distance of 10 cm to the second OPC. Noticeable when emitting the samples is the different composition of dust. Especially dust taking from poultry barns is different in regard to their cotton similar composition. Therefore a smoth and area-wide output is difficult to achieve. Due to their finer structure this problem is not encountered when emitting pig or cattle dust samples. For every species and each measurement a sample of 1.0 g dust is emitted. Each measurement cycle takes 15 minutes.

Data basis

In order to make a statement on the fraction of resuspended particles knowledge about the particle size distribution for the emitted dust is necessary. For this purpose the measured particle distribution based on earlier performed emission measurements in barn complexes is regarded. This particle distribution is used to calculate the particle distribution for 1.0 g of dust emitted in the wind channel.

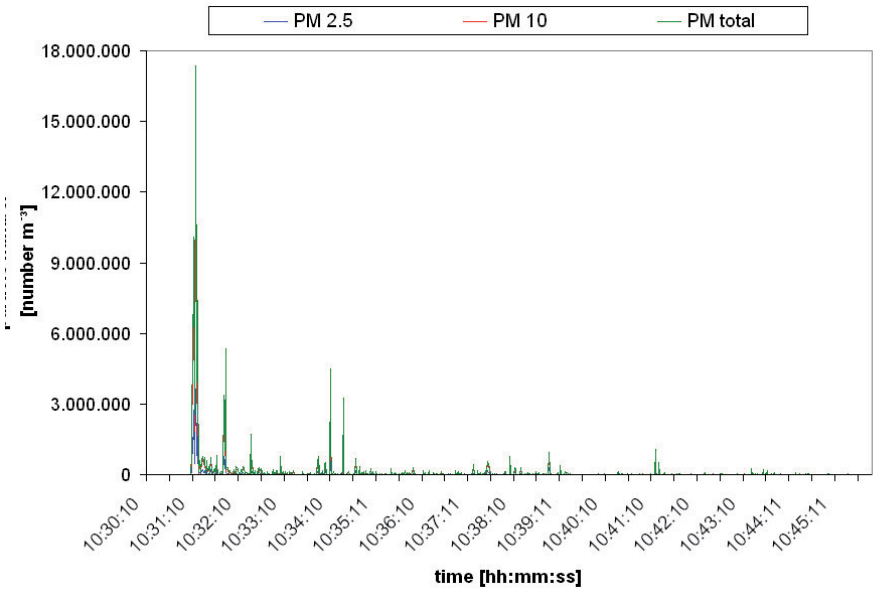
The number of resuspended particles is measured with the OPC. Using the earlier determined specific density [4] the mass of suspended particles can be calculated. Therefore the fraction of suspended particles in the emitted dust sample can be determined.

First results

Figure 2 shows a sample measurement for a dust sample taken from a dairy cattle barn (1.0 g) and an average wind velocity of 3.3 m s^{-1}. The particle number concentration was further divided into the particle size fractions $PM_{2.5}$, PM_{10} and PM_{total}.

It can be seen that there is no continous swirling of particles and the particle layer is not completely removed in the course of one 15 minutes lasting measurement. In fact at temporal-

Fig. 2



Measurement of resuspension: average wind velocity 3.3 m s^{-1} and a dairy cattle barn dust sample of 1,0 g

ly undetermined points single particles enter the air flow [1] which results in single resuspension peaks. Furthermore it is visible that in the beginning more particles resuspend and the number of dissoluting particles decreases in the course of the measurement to a low level.

The calculated per cent fraction of resuspended particles can be found in **figure 3**. The particle mass distribution is shown for a sample of 1.0 g from a dairy cattle barn and for different size fractions. The biggest fraction of particle mass can be found for sizes between 4.0 and 15 µm. The fraction of suspended particles in dependency of wind velocity relates to the resuspended particles as measured by the OPC. The background concentration was taken into consideration.

As expected an increasing wind velocity leads to more particles in the air flow.

For low wind velocities, that are dominant near to the floor of agricultural barn complexes, the fraction of resuspended particles can be expected as very small.

However differences between different animal species can be found that can most likely be ascribed to different composition and other properties.

Conclusions

In the last years the number of dust emission measurements in animal barns has significantly increased. The emission factors for different kinds of livestock could be determined more precisely, leading to an improved prognosis for imission loads [6].

Systems designed to reduce the dust amount in barns, as well as exhaust air cleaning systems were optimised for poultry and pig barns [2] so that the emitted dust amount from animal barns lies under the limits given by law [5].

Now it is to be measured what factors affect the transmission of dust in order to improve predictions. In regard to resuspension it is however very difficult to develop models [3]. With our measurements we contributed to the question of resuspending particles around agricultural facilities. However a lot of research work has to be done in this area in order to allow reliable predictions by dispersion models.

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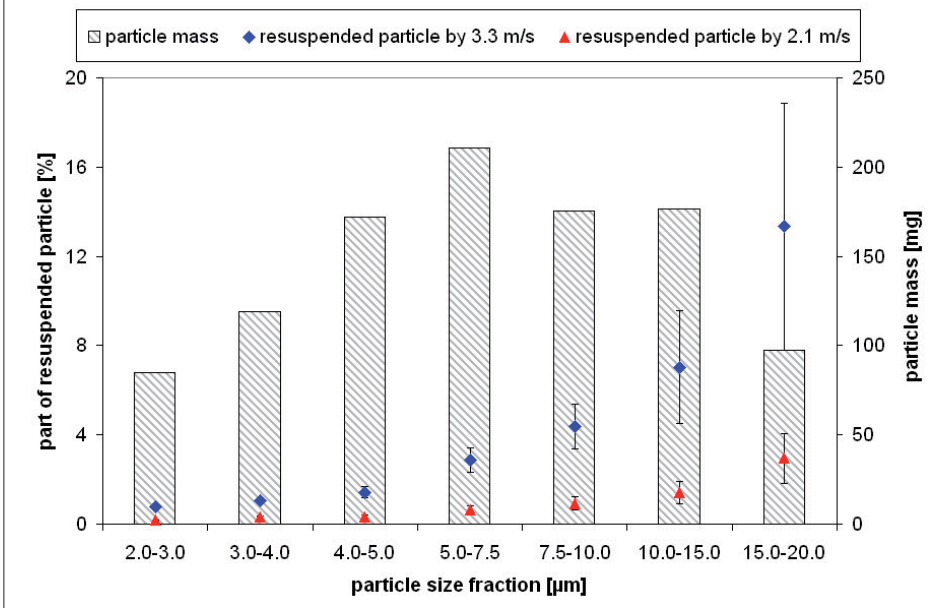
Fig. 3



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