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Effect of Animal Activity on Dust Release and Particle Emissions

Investigations in Pig Fattening Houses

In the field of animal activity research there are several investigations which include the total dust content in waste air. By using suitable measuring devices, which provide data on particle size distribution in waste air, new knowledge can be gained about the interrelationship with animal activity. Preliminary results of an ongoing project are presented. With increasing particle size and a relatively constant volume flow the relationship between animal activity and source emission becomes narrower.

The relationship between animal activity and dust content (r = 0.87 to r = 0.66) in the interior air of livestock houses, which was first verified by [1] 1993, has an effect on the dust emissions from livestock buildings that should not be underestimated. Measurements by [2] in 1996 produced similar results. They measured animal activity using infrared video technology instead of PIRs (passive infrared sensors) for the purpose of analysing the animals' pattern of behaviour. Previous studies have only drawn connections between animal activity and total indoor dust concentration, but without analysing in detail the particle sizes in the exhaust air and, consequently, without analysing their impact on the emissions. According to [3], there are differences in size composition between indoor dust concentrations and dust concentrations in exhaust air. The goal of the present investigations has been to analyse additional aspects of the connection between animal activity and dust. The following will report on initial results that must be pursued further in the course of the project.

Method

Diurnal variations in the parameters animal activity, particle concentration and air volume flow rate were recorded on three days with different weather conditions in order to facilitate the analysis of the connection between animal activity and particle emissions. The investigations were made in a fattening house for 112 pigs with dry feeding (ad libitum) and door ventilation.

Activity logging

The sensors used in this study are commercial passive infrared sensors modified for this particular application. The integrated relay control for the prevention of interferences has been deactivated. Instead, a voltage is tapped directly from the sensor so that it maps a signal that is analogous to the recorded movement. The signal is a differential signal, i.e. rapid temperature increases or decreases in front of the sensor lead to higher positive or negative values than slow changes in temperature. Thus, the amplitude of the impulse is proportional to the intensity of the temperature change. Slow temperature changes induce no signal. Signals are first rectified for further processing so that temperature increases and decreases are no longer differentiated. The incoming signal is then routed through a holding circuit so that short impulses are artificially prolonged; the duration can be adjusted on the sensor. Thus, a data logger 2590-9 (Ahlborn, Holzkirchen, Germany) that records the voltage every six seconds can capture short movements as well. At first, the measured values were averaged over one minute. Then, moving half-hour averages were calculated on the basis of these one-minute values.

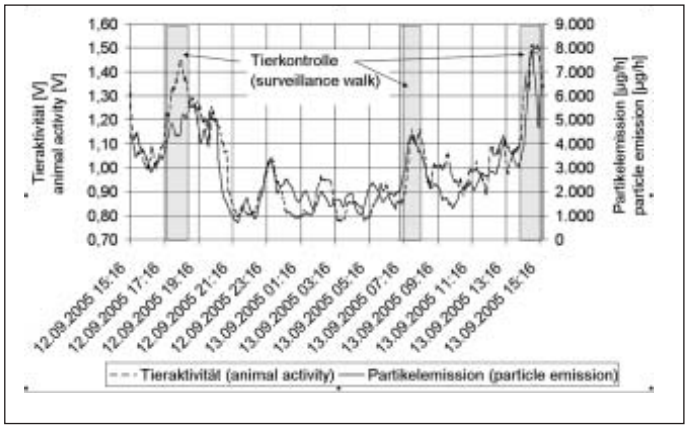

Fig. 1: Daily animal activity and particle emission

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Keywords

Dust, animal activity, air volume flow, dust sources, particle size, fattening pigs

Literature

Literature references can be called up under LT 06106 via internet http://www.landwirtschaftsverlag.com/landtech/local/literatur.htm.

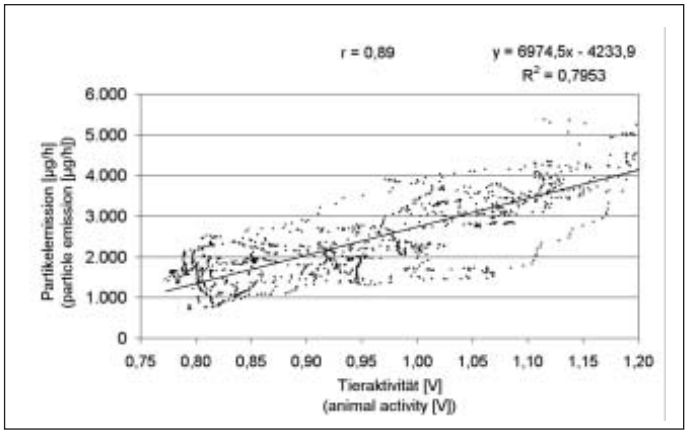

Fig 2: Animal activity versus particle emission

Particle concentration measurements
The continuous particle measurements were carried out in accordance with standardised measuring instructions for occupational safety and health [4, 5]. Particle concentrations were measured with an aerosol spectrometer, model 1.105 (GRIMM-Aerosoltechnik, Ainring, Germany). Isokinetic sampling in the exhaust air flow was carried out on the intake side. The measuring interval was one minute.

Air flow monitoring
A calibrated measuring fan with a data logger (as above) for monitoring the frequency of the fan was used to monitor the volume flow rate. The measuring interval in this case was one minute as well. The measuring fan was positioned on the pressure side of the exhaust shaft.

Particle emission
Particle emission (µg/h) is calculated by multiplying particle mass by volume flow rate. For the calculation of the correlation, the one-minute values were transformed into moving half-hour values. Air volume flow rate has an influence on particle size distribution. The higher the volume flow rate, the greater is the proportion of particles with greater equivalent diameters. In the analysis of the different size classes this interrelation could be disregarded because the difference between diurnal and nocturnal temperature was only three K and the changes in the air volume flow rate were minimal.

Results

The results of the measurements by [1] and [2] were confirmed by the measurements made for the present study. The example of the development of animal activity and particle emission for one day as depicted in *Figure 1* shows that especially surveillance walks are connected with high animal activity and consequently with high particle emission. Animal is at a relatively constant level while the automatic feeders are being refilled. This may be explained with ad libitum dry feeding, because in this feeding system animal behaviour hardly changes at the beginning of feeding time. Except during heightened activity during surveillance walks, it is thus possible to trace the animals' „biorhythm". As a result of compulsory night lighting, the activity level of the animals in the fattening compartments changes only very little (—> pigs as crepuscular animals).

The question arises to what degree animal activity and particle emission are correlated. *Figure 2* contains the scatter plot of the correlation. As expected, the calculated coefficient of determination across all size classes ($R^2 = 0.8$) shows the correlation between animal activity and particle emission to be high. The developments on the other two days were at $R^2 = 0.63$ and 0.71. The results confirm the expected relationship.

In this first analysis a new aspect was found regarding particle size distribution. Representative for all daily developments, *Figure 3* shows the correlation coefficient to be increasing as particle size increases. The larger the particles, the closer is the correlation with animal activity. The coefficients of determination were computed by comparing the half-hour means from the animal activity measurements with the half-hour means for the corresponding size classes determined with the aerosol spectrometer.

Discussion

As a result of a higher level of animal activity, the air contains a greater number of larger dust particles which would otherwise have remained on the floor on the equipment due to their sedimentation behaviour. Increases in the total particle number concentration [l/m³] are negligible, whereas increases in the particle mass flow are significant because these larger particles account for a great proportion of the total mass. By contrast, even without animal activity there is a relative constant proportion of small particles in the exhaust air. Unnecessary activity peaks should be avoided because increasing animal activity leads to higher dust emissions.

With regard to the development on the day looked at above, the good correlation coefficient is mainly due to the negligible changes in the air volume flow rate. For the other two days, the correlation coefficients are not on a comparable level because on those days the air volume flow rate changed more noticeably as a result of lower night temperatures and higher daytime temperatures. [6] assumed in their study that if the particle distribution in the exhaust air was assumed to be homogeneous, then the same dust concentration had to be observable inside the building as well. This assumption was proved to be wrong by the present investigations. The higher the volume flow rate, the lower is the dust concentration and the higher is the correspondence between the dust concentration in the interior air and in the exhaust air.

Conclusion and outlook

Animal activity and particle emission levels are closely correlated. Emissions increase drastically especially during periods of activity. One of the reasons for this is the increasing proportion of larger particles in the total number of particles. The initial results presented here shall be supported and confirmed in further investigations for this project. Measures for the reduction of emissions can only be assessed if the source and the course of increased emissions are known. That should be one aim of the new investigations. Moreover, on the basis of animal activity, it is possible to deduct the animals' biorhythm as well as their „normal behaviour". In the future, this might play a role as an indicator of animal welfare and in detecting diseases.

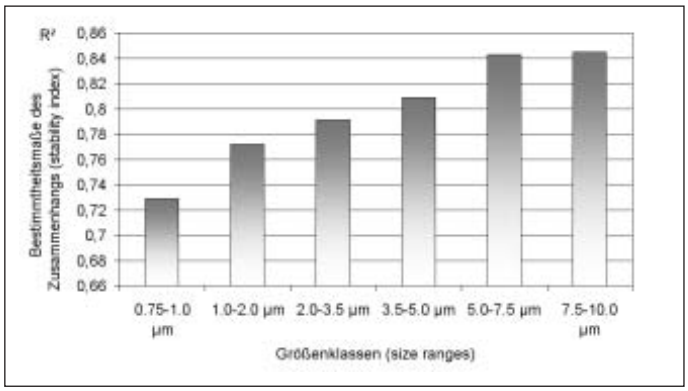

Fig 3: Calculated coefficients of determination between animal activity and particle emission in various size ranges