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Optimizing a Recirculating Air Scrubber for Reducing Particulate Concentration in Animal Houses

Odours, ammonia and dust develop in animal houses, which on the one hand must be mitgated for environmental reasons, and on the other hand must be removed from the interior because of the housing needs of the animals. In layer hen housing, because hen keeping in cages has been forbidden, stable facilities are currently being equipped with alternative stalling systems, like floor management or aviary systems. They get high marks from the animal welfare viewpoint, but have higher emissions, especially dust, compared to cage keeping [1]. Not only the environment, but also the farmer and the animals are exposed to higher dust concentrations. In the following, preliminary results on a wet filter system for improving air quality are presented.

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Keywords

Dust, particle size, layer hen, particle filter

Bioaerosols in animal houses consist of mainly feed and fecal components, and if present, litter, minerals and organic materials. The organic particles have a biological origin and biological activity [2]. They can thus release allergenic, toxic, infectious, and pharmacological products. This organic component group includes microorganisms such as bacteria, fungi, viruses, dust mites, yeast, and protozoa and also their byproducts, including endotoxins, mycotoxins and ß-Glucose. The inorganic particles in bioaerosols are called dust. In this context, occupational health studies show the harmful effects of the dust particles to the human respiratory tract. The nature of this damage depends on the various physical and chemical parameters of the particles [3]. Relevant factors include size, density and shape.

The aim of this investigation was to install a wet filter system inside the laying hen house with optimal water pressure and air velocity conditions in order to achieve the highest possible efficiency for reducing indoor dust concentration and emissions.

Method

The measurements were performed under laboratory conditions at the Institute of Agricultural Engineering in Bonn University. The wet filter system used was designed by modifying an existing system at the institute [4]. *Figure 1* illustrates the operating principle of the recirculation system. It consists of an approximately 1.30 m long channel with an inside diameter of 630 mm, nozzles for spraying the water, a fan move the air through the scrubber and filtering materials (a mist eliminating component). The wastewater exiting the filter is a mixture of water and the residual substances such as dust. This waste must be discharged into suitable temporary storage facilities.

The experiment setup is represented in *Figure 2*. The wet filter system was located between two exhaust pipes with a diameter of 900 mm each. Dust particles collected from the laying hens house were injected inside the system using a Venturi nozzle. The airflow carried these particles through the wet filter and out after cleaning them at the other end of the experiment system. In two sample places, before and after the scrubbers, aerosol spectrometers were installed to determine the particle concentration. The aerosol spectrometers operate by measuring light scattered from the particles, recognizing 15 different classes of particle sizes (0.3 µm to> 20 µm). The flow rate did not exceed 2 m/s. Accordingly , the measurements were taken using a radial symmetric sampler.

Results and discussion

Using the measurement setup described, it was possible to determine the optimal water nozzle pressure and air velocity in the scrubber necessary for reaching the highest dust reduction efficiencies. *Figure 3* shows the best results, which were obtained with an air speed of 6 m//s and a water pressure of 2.5 bar. A water pressure of 2.5 bar corresponds to a flow of 0.18 litres per minute with the

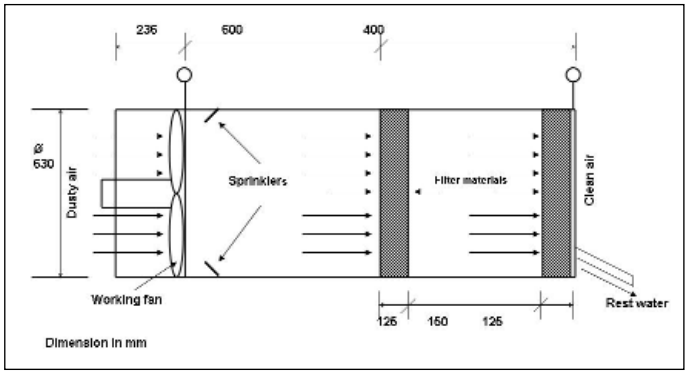

Fig. 1: Function principle of the wet filter systems

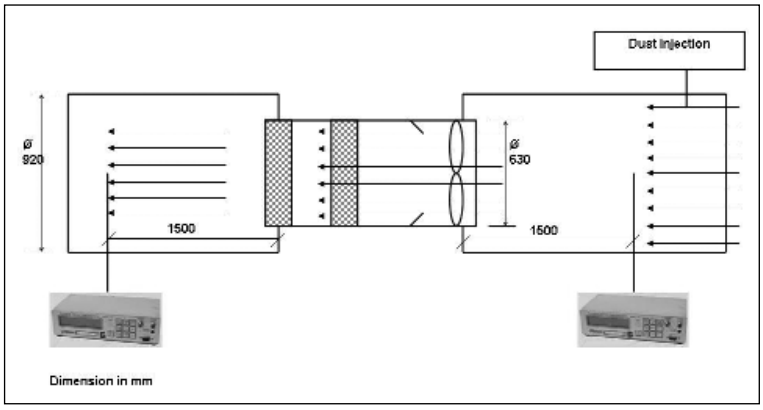

Fig. 2: Laboratory measurement set-up for determining the degree of particle reduction

assigned nozzles. However, because deviations between the individual variants were not very large, further investigation should be run at an air velocity of 4 m/s and a water nozzle pressure of 1 bar (0.11 litres/min) in order to conserve both water and energy.

The scrubber was tested afterwards under the adjusted conditions in a small laying hens house at the experimental station (Frankenforst) of the University of Bonn. The purpose of this testing was to measure the efficiency of the scrubber and its ability to reduce the emission and concentration levels of the targeted pollutants in the stable. *Table 1* shows the results of this investigation. Under the operating conditions used in the practical measurements, a slightly higher scrubber efficiency was observed in comparison to that determined from the laboratory measurements. Complete circulation of the standing air in the stable was never realized. These results are consistent with the studies of [5, 6 and 7] and were higher than the investigation of [8].

Conclusion and outlook

From the basic laboratory measurements of the wet filter system, optical process conditions for reducing particle concentration and minimizing maintenance costs were calculated. With a flow rate in the scrubber of 4 m/s and a water pressure of 1 bar, efficiencies of over 85% were reached. The measurements have been taken in the laying hens house with an aviary system using the aforementioned process conditions. With this system it was possible to significantly reduce the indoor dust concentration in the laying hens house. This will not only improve the environment but also the working conditions of the personnel and the living conditions of the animals.

However, good air circulation must be present in the stable in order to increase the probability that contaminants will reach the scrubber. In poultry houses with large amounts of moving air, it would be better to employ several scrubbers to achieve this high volume flow. Thus, the next goal in the continuing development of this wet filter system is reducing the costs.

Table 1: Efficiencies under practical conditions in different particle fractions

Efficiency in %	$PM_{2,5}$	PM_{10}	Total dust
Scrubber	81	92	95
Indoor dust concentration	24	30	29
Dust emission	33	51	52

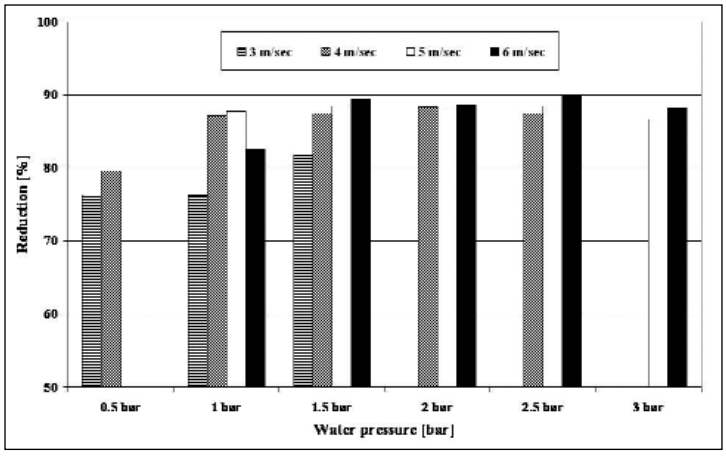

Fig. 3: Results of the laboratory measurements by illustrating the system efficiencies relating to air velocity and water pressure

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