Kathrin Fleming, Engel F. Hessel and Herman Van den Weghe, Vechta

Gas and Dust Formation from Various Bedding Materials for Horse Keeping

In a technical trial various bedding materials were tested for their suitability in horse keeping under standardised conditions. Straw pellets achieved good ammonia binding results in this examination. Airborne dust formation from hemp and linen was significantly higher than with other selected materials. Straw pellets seem to be practicable for creating an optimal stable climate. To corroborate these hypotheses, further research in practice is required.

M.Sc. agr. Kathrin Fleming is a postgraduate student at the Research Center of Animal Husbandry Weser- Ems of the Georg-August-University Göttingen in Vechta, Driverstr. 22, D-49377 Vechta; e-mail: *kathrin.fleming@agr.uni-goettingen.de*
Dr. Engel F. Hessel is a scientific assistant and Prof. Dr. Ir. Herman Van den Weghe is head of the Research Center.

Keywords

Horse keeping, litter, dust, ammonia

Literature

Literature references can be called up under LT 07410 via internet http://www.landwirtschaftsverlag.com/landtech/local/literatur.htm.

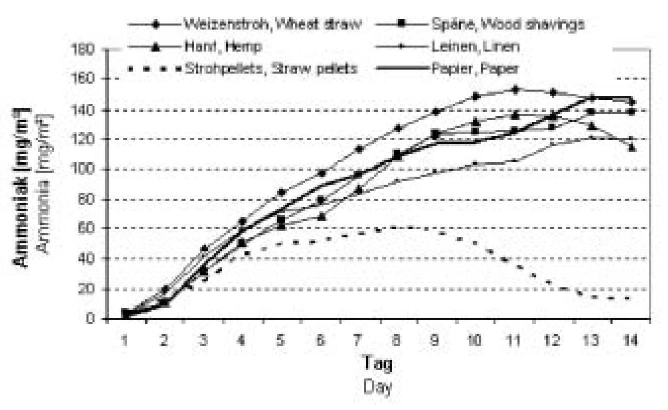

Fig. 1: Ls-means of the NH_3 concentrations of the various bedding materials over a period of 14 days

The air quality in horse stables, which is mainly characterised by air temperature, relative air humidity, air circulation, gaseous and airborne dust concentrations, plays a decisive role for the animal health. The equine respiratory tract reacts very sensitively to airborne particles and noxious gases [1, 2]. The main part of the more than 1 million horses in Germany is stabled in single pens, in the breeding and leisure as in the sport sector as well [3, 4]. Earlier investigations proved that practical horse housing, which is often accompanied with insufficient air quality, is responsible for many respiratory diseases [5, 6]. Many horses spend the most of their lives, up to 23 hours per day in their stall and consequently, they are exposed to a constantly polluted environment [7, 8]. Among other factors, the litter has, due to material specific differences, an important effect on the stable air quality with respect to the airborne dust and gas formation and the water and ammonia binding capacity [9, 10, 11]. The aim of this study was to analyse and compare six different bedding materials for horse stables under standardised conditions with regard to their acceptability as bedding materials for horse housing. Thereby diverse influential factors of the gaseous emissions of different litter substrates were detected and evaluated. The study was assigned to find out, which material is suited for an improvement of the stable climate and a reduction of the gaseous emissions to create conditions for an optimum stable environment for horses.

Material and methods

The following bedding materials were analysed under standardised conditions: wheat straw (not chopped, blade length 20-30 cm), dedusted wood shavings, hemp (shives), linen straw (shives), straw pellets (from wheat straw, grinded and pelleted), paper cuttings (unprinted newspaper, 1 cm • 6 cm). The litter materials were analysed with respect to their airborne dust formation in different particle fractions and their emission behaviour, in particular their ammonia binding potential. In addition, the total carbon and nitrogen contents, the C/N ratios, the water holding capacities and the particle size fractions were determined. Furthermore, at the beginning of the trial and at the end of three successive trial periods, the mould fungi and bacteria contents as well as the total germ count of the different materials were also examined.

For the gas analysis, 12 containers (size 500 l) were constructed in an environmentally controlled room. The containers were covered but they were permeable to air. The concentrations of ammonia (NH_3), carbon dioxide (CO_2), nitrous oxide (N_2O) and water vapour (H_2O) were measured quasi-continuously online during the whole trial period via the multi-gas monitor 1312 and the multiplexer 1309 from INNOVA AirTech (Denmark). Moreover, sensors were inserted in each container to measure the temperature inside and above the substrate. The same material was filled in two containers; the amount depended on the carbon content (1500 g). Over a period of 14 days, a defined portion of nitrogen (horse manure/urine mixture; 220 g) was added daily to each container. The horse manure/urine mixture was collected for each trial period and was stored in a cooling chamber and additionally, the carbon and nitrogen content of the manure/urine mixture was determined. The trial was repeated six times, three repetitions each with a room temperature of 22°C, 13°C, respectively to simulate summer and winter season. At the beginning of the trial and at the end of three successive trial periods, a sample of each material was analysed microbiologically.

For the airborne dust analysis, a special closed chamber was constructed (d = ~ 50 cm), which includes a barrel with rotating paddles. A certain amount (volume 20 l) of each litter material was filled into the barrel (wheat straw 1 kg, wood shavings 2 kg, hemp 2,4 kg, linen 2,2 kg, straw pellets 6 kg, paper cuttings 2 kg). The rotation of the paddles was driven by a small motor, whereas the speed (variable 1 = 14 rotations per minute); variable 2 = 8 rotations per minute) and the duration of rotation (variable 1 = 1 min; variable 2 = 5 min) could be varied. The dust formation of the materials was measured continuously during the rotation and several hours afterward. The dust analyser (TEOM 1400 a, Rupprecht & Patashnick, USA), which was also located in the chamber, measured the development of different airborne dust fractions TSP (PM_{20}), PM_{10}, $PM_{2.5}$ and PM_1. For each material three repetitions were carried out. The statistical evaluation of the data points was carried out with statistical program SAS (SAS Inst. Inc., Cary NC, USA). Data points, which did not offer a normal distribution, were transformed by logarithmic calculus, before an analysis of variance was carried out by using the procedure GLM. Influences of fix effects on the gas formation were estimated. Fix effects were the 'material', the 'season' and the 'trial period'. To analyse the airborne dust values, minute 15, 30, 45, 60, 75, 90, 105 and 120 after rotation were compared to each other. Furthermore, 2 hours averages were calculated. For the dust analysis, the influences of the fix effects "material", "time" and "duration" were estimated.

Results and discussion

The results of the gas analysis showed that the room temperature had an influence on the gas formation in the container. Under warm conditions with room temperatures about 22°C, the NH_3 concentrations were significantly higher than the concentrations under cold environmental conditions with

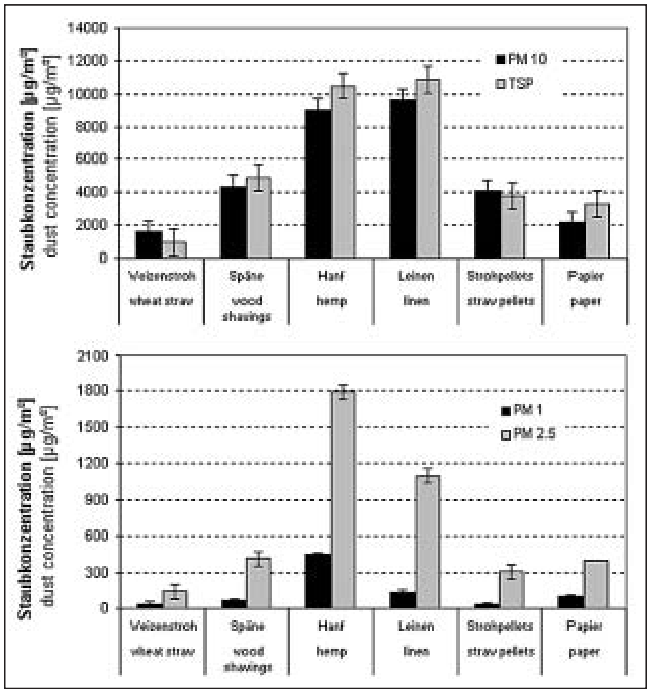

Fig. 2: Ls-means and standard errors of the airborne dust concentrations (PM_1, $PM_{2.5}$, PM_{10} and TSP) of the different materials two hours after starting rotation of the paddles; 1 minute rotation; 14 rotations per minute

temperatures about 13 °C. With regard to the NH_3 formation over a period of 14 days, some differences between the litter materials were observed. The NH_3 concentrations of all materials increased continuously in the first days of the trial. In general, the emissions of straw pellets, linen straw and hemp bedding were lower than the values of wheat straw, wood shavings and paper cuttings. After the seventh day the concentrations of the straw pellets stayed stable, while the concentrations of the other materials consistently increased. The NH_3 concentration of the straw pellets decreased after the ninth day. The concentrations of hemp also decreased after day 10. The daily least square means of the NH_3 concentrations over a 14 day period are illustrated in *Figure 1*.

Because of their preparation, the straw pellets exhibit a big assailable surface for micro organisms. The availability of carbon is basically higher than in unconditioned straw for example. It is to be assumed that the declining NH_3 concentrations of straw pellets are caused by increasing nitrification processes. During the nitrification NH_3 and NH_4^+ respectively are oxidized via intermediate stages to nitrate (NO_3^-) by specialised bacteria. In this study further indicators were determined, which support the assumption of increasing nitrification processes. At the point where the NH_3 formation of the straw pellets decreased, increasing CO_2 and H_2O values could be detected within the pellet containers in comparison to the other materials. Moreover the substrate temperature with maximum values up to 40 °C was significantly higher (see *Figure 2*). Energy in terms of CO_2 and heat were released by the cumulative activity of bacteria. Furthermore, significantly higher N_2O concentrations were measured with straw pellets. N_2O is generated almost exclusively by microbiological processes. It is a by-product of incomplete denitrification processes caused by the presence of O_2.

Regarding the dust formations, hemp bedding and linen straw had the significantly highest airborne dust concentrations. In particular, concentrations of particle fractions PM_{10} and PM_{20} of hemp bedding and linen straw were more than 100 % higher than the values of wood shavings and wheat straw pellets as well as more than 200 % higher than the concentrations of paper cuttings and wheat straw. The measurements of the smaller particle fractions PM_1 and $PM_{2.5}$ showed similar results. The concentrations of hemp bedding in the fraction PM_1 were 300 % higher than linen straw and almost five times higher than paper cuttings. The lowest concentrations were measured for wheat straw, paper cuttings and straw pellets (*Fig. 2*).

The extension of the rotation time from one to five minutes caused a significant enhancement, approximately a tripling, of the airborne dust concentrations of each material. The rotation reduction of the paddles from 14 to 8 rotations per minute caused a significant decrease of dust concentrations of each material.

Conclusion

With respect to ammonia binding, the straw pellets attained positive results. The airborne dust formation of hemp and linen was extensive. The concentrations were significantly higher than the concentrations of the other materials.

In conclusion of this study, the results showed that the straw pellets seem to be suitable for horse stables to support an optimal stable climate with regard to ammonia emission and airborne dust formation. To evaluate these results, further research under practical conditions is required.