Reiner Brunsch, Annett Model, Eike Scherping and Werner Berg, Potsdam

The Influence of Litter Material and Processing on NH_3 and Trace Gas Emissions from Layer Hen Husbandry

In laboratory trials, various kinds of differently processed straw as well as materials such as peat and lignite were examined with regard to their effect on the emission of noxious gases during the storage of layer hen droppings. Each one of the examined noxious gases (NH_3, CH_4, N_2O) showed a different behaviour towards the examined litter materials. Therefore, no definitive recommendation can be given as to which one of these materials limits the emissions of all three noxious gases equally well.

Prof. Dr. habil. Reiner Brunsch is acting director of the Leibniz Institute of Agricultural Engineering Potsdam-Bornim (ATB), Max-Eyth-Allee 100, D-14469 Potsdam;
e-mail: *rbrunsch@atb-potsdam.de*
Dr. Annett Model and Dr. Eike Scherping were scientists working at the ATB.
Dr.-Ing. Werner Berg is a scientist working in the Department of Technology Evaluation and Material Cycles of the ATB.

Keywords

Layer management, litter material , noxious gases

Transition to floor husbandry techniques for layer hens raises the question of which litter materials are appropriate in order to keep emissions of the environmentally harmful gases ammonia (NH_3), methane (CH_4), and di-nitrogen oxide (N_2O, “laughing gas”) to a minimum. The studies focused on straw of different cereals and processing forms. In addition, peat, soft wood shavings, and lignite were examined. The goal of the studies was a comparison of the mentioned materials. The determined absolute emission flows are different from those which occur under practical conditions.

Material and Methods

The fresh layer hen droppings were mixed intensively with the materials shown in *Table 1* in a mass ratio of 20 : 1 (droppings : litter; exception: straw pellets and lignite: mixture ratio 10 : 1) and stored in 6 cm layers in acrylic glass containers (*Fig. 1*). Mixing led to the destruction of the dung balls, which is unlikely to occur in the layer hen stall. In five measurement series, the 20 variants were randomly distributed over 12 containers per series so that every variant was able to be measured three times altogether. The measurement of gaseous emissions took place under laboratory conditions (air temperature: 20 °C) on 7 to 9 measuring days, which were distributed over 9 to 11 consecutive calendar days per trial series. During gas measurement, the storage containers were closed, and 25 litres of air per minute flowed through. Gas concentration was measured using a photo-acoustic gas monitor (Bruehl & Kjaer/Innova). After the individual mixtures had been prepared, samples were drawn from each container, of which the dry matter (DM)-, total nitrogen (N_t-) and ammonium nitrogen (NH_4-N-) content as well as the pH-value were determined. The reference value used for the gas flows of NH_3 and N_2O was the total nitrogen content, while the dry matter content at the beginning of the trial served as reference value for CH_4.

Fig. 1: Experimental container with a mixture of short-chopped wheat straw and layer hen droppings

The gas flows themselves were calculated based on differences in concentration between ingoing and outgoing air, which were accumulated over a period of nine calendar days.

Results

Ammonia

In all examined variants, NH_3 emissions decreased continuously from the first until

Table 1: Description of the variants

Nr.	Material	Index	Processing	Index
1	barley	1	uncomminuted	a
2	barley	1	chopped 40 mm	b
3	barley	1	chopped 10 mm	c
4	barley	1	spliced	d
5	rye	2	uncomminuted	a
6	rye	2	chopped 40 mm	b
7	rye	2	chopped 10 mm	c
8	rye	2	spliced	d
9	wheat	3	uncomminuted	a
10	wheat	3	chopped 40 mm	b
11	wheat	3	chopped 10 mm	c
12	wheat	3	spliced	d
13	oats	4	uncomminuted	a
14	oats	4	chopped 40 mm	b
15	oats	4	chopped 10 mm	c
16	peat			5
17	lignite			6
18	soft wood shavings			7
19	barley-wheat pellets			8
20	wheat pellets			9

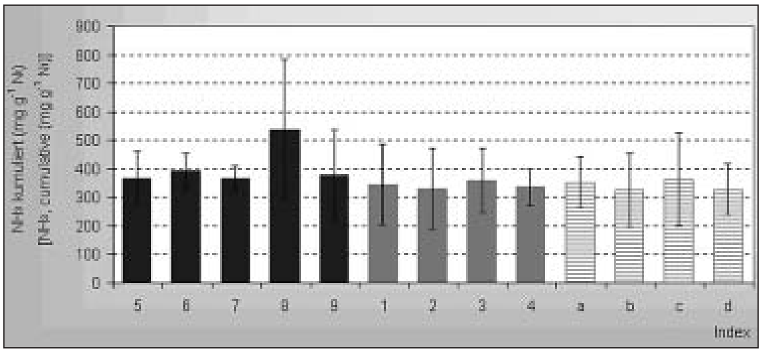

Fig. 2: Cumulated NH_3-emissions (mg NH_3 g^{-1} N_t) depending on type of litter and processing

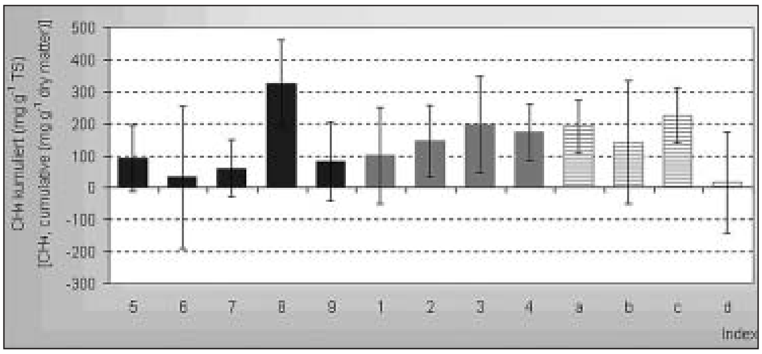

Fig. 3: Cumulated CH_4-emissions (mg CH_4 g^{-1} DM) depending on type of litter and processing

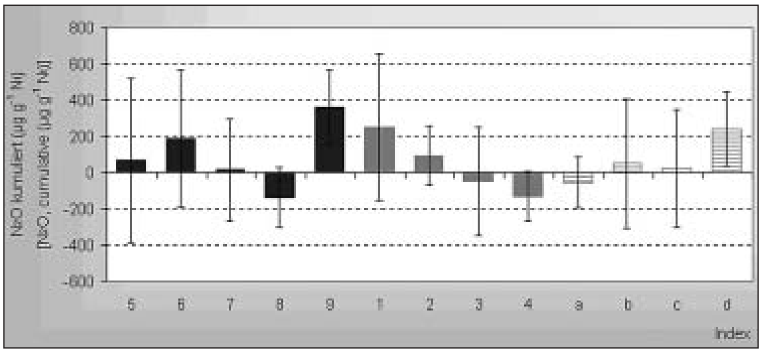

Fig. 4: Cumulated N_2O-emissions (µg N_2O g^{-1} N_t) depending on type of litter and processing

the last day of measurement. On average, the emission rates of the last day of measurement reached 37% of the emissions observed on the first trial day. The measured emission rates ranged from 0.14 mg to 4.6 mg NH_3 g^{-1} N_t h^{-1}. Depending on the kind of straw that was mixed in, accumulated values between 331 mg NH_3 g^{-1} N_t (rye straw) and 359 mg NH_3 g^{-1} N_t (wheat straw) were measured. The other litter materials used (peat, lignite, soft wood shavings, pellets) caused accumulated emissions of 376 mg NH_3 g^{-1} N_t (soft wood shavings) to 538 mg NH_3 g^{-1} N_t (barley + wheat pellets). For the individual kinds of processing of the cereal straw (including pelleting), emissions between 325 mg NH_3 g^{-1} N_t (chopping length: 40 mm) and 457 mg NH_3 g^{-1} N_t (pelleted) were measured (*Fig. 2*).

Methane

CH_4 emissions decreased continuously towards the end of the trial. In the second half of the trial period, a large number of negative balance values were measured regardless of the examined variants. All in all, the CH_4 flow rates ranged between + 7.8 mg CH_4 kg^{-1} DM (variant 19) and –2.2 mg CH_4 kg^{-1} DM h^{-1} (variant 4). On average, the emission rates of the last trial day reached 1.5% of the emissions observed on the first day of the trial. When the kinds of straw used were compared, the accumulated maximum emission of 196 mg CH_4 kg^{-1} DM was determined for wheat straw. These emissions were almost twice as high as the minimum value measured for barley straw (100 mg CH_4 kg^{-1} DM). The litter materials used in addition to cereal straw (peat, lignite, soft wood shavings, pellets) caused accumulated emissions ranging from 32 mg CH_4 kg^{-1} DM (lignite) to 325 mg CH_4 kg^{-1} DM (barley-wheat pellets). The accumulated emission values for the individual kinds of processing (including pelleting) showed a similar degree of straggling. At 226 mg CH_4 kg^{-1} DM (chopping length 10 mm), the maximum value was 13 times higher than the minimum value of 17 mg CH_4 kg^{-1} DM (spliced) (*Fig. 3*).

Di-nitrogen Oxide

On all three trial days, both positive and negative balancing results were determined. Accordingly, the difference between the highest and the lowest emission rate was 128.3 µg N_2O g^{-1} N_t h^{-1} on the first trial day and 18.8 µg N_2O g^{-1} N_t h^{-1} on the last trial day. On average, the emission rates of the last day of measurement reached 8.9 % of the emissions observed on the first trial day. Depending on the kind of straw used, accumulated values between 252 µg N_2O g^{-1} N_t (barley straw) and –131 µg N_2O g^{-1} N_t (oat straw) were measured. For the other materials examined in addition to straw (peat, lignite, soft wood shavings, pellets), accumulated emissions ranging from 362 µg N_2O g^{-1} N_t (wheat pellets) to –138 µg N_2O g^{-1} N_t (barley-wheat pellets) were calculated. For the individual kinds of processing of the cereal straw (including pelleting), accumulated emissions ranging between 242 µg N_2O g^{-1} N_t (spliced) and –56 µg N_2O g^{-1} N_t (uncomminuted) were determined (*Fig. 4*).

Discussion and Conclusions

In some cases, the litter materials showed significant differences in the gas flows from the dung-litter mixture, which, however, exhibited a large range of variation due to the chosen experimental approach (random distribution of the variants over the measurement series) so that the differences cannot be proven in a statistically significant manner. Due to low concentration values of N_2O and CH_4, the balance values for some trial days and variants were negative. Intensive mixing led to the destruction of the dung balls and, hence, to conditions which cannot be compared with those encountered in practice. For this reason, the emission rates cannot serve as a basis for emission factors in practice.

The larger specific surface caused by the splicing of straw generally did not lead to the expected change in emissions as compared with other kinds of processing. The very large fluctuations of the emission rates between the individual measurement series indicate that the influence of the individual series may have concealed other factors to a significant extent and thus prevented clearer results. Current knowledge does not justify any recommendation of “particularly emission-reducing” litter materials.