PM 10 MEASUREMENTS IN A TURKEY BARN
- FIRST RESULTS, METHODS AND LIMITATIONS

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INTRODUCTION

There is increasing concern, that air pollutants such as dust particles may have a negative effect on the respiratory health of the German population. It was recognised in recent years, that particularly fine particles of sizes lower than 10 µm can penetrate through into the deeper respiratory tract causing irritations and supporting inflammation. Therefore, more attention was paid to this particle fraction which is called PM10 (Particulate Matter < 10 µm). The main contributors to this particle fraction are industries, traffic and household combustion. It is assumed that also livestock production facilities are contributing to the PM10 emissions via primary and secondary particles (Ammonia as pre-cursor). Some recent monitoring results in the north of Germany revealed high concentrations of PM10 in areas with high livestock production [1]. These observations however were not directly related to animal house emissions. There is a lack of knowledge on the emission amounts of PM10 from intensive livestock farming.

This paper reports on some orientating measurements of airborne PM10 particles in a turkey barn, using a specific aerosol sampler designed for measuring PM10 in ambient air. The results are compared to some conventional filter techniques for measuring airborne dust and to assess the possibility to establish conversion factors, which may allow the transformation from inhalable dust into PM10. The methods, their limitations and first results obtained by the aerosol sampler are reported.

MATERIAL AND METHODS

The measurements were performed in a naturally ventilated turkey barn with approximately 1,600 male turkeys (race Big 6, Lohmann, Cuxhaven, Germany) resulting in a density of 3.5 birds per m². In Figure 1 some elements of the animal house with automated feed trufs (tube at the right hand side in the picture) and round drinkers can be identified. Wood shavings were used as bedding material. The bedding is worked up by some sort of the harrow mixing old and new litter to avoid heavy compression of the bedding and formation of hard surfaces. This procedure was generally carried out once a week. Sometimes additional bedding material was needed nearer to the drinkers where wet litter was recognized. Herd inspection was performed by the animal caretaker at least once a day by walking slowly through the animal house to see each animal moving according to animal welfare regulations.

In figure one the position of the PM10 sampler (Type Digitel DHA-80, Riemer Messtechnik, Hausen/Rhön, Germany) can be recognised. The PM sampler was placed right of the longitudinal axis nearly in the middle of the animal house. This sampling system is designed for discontinuous sampling of dust with a particulate matter size of less than 10 µm (PM10). Dust is sampled on filter disks, stored in a magazine. Filter changes can be normally adjusted between 1 and 24 hours.

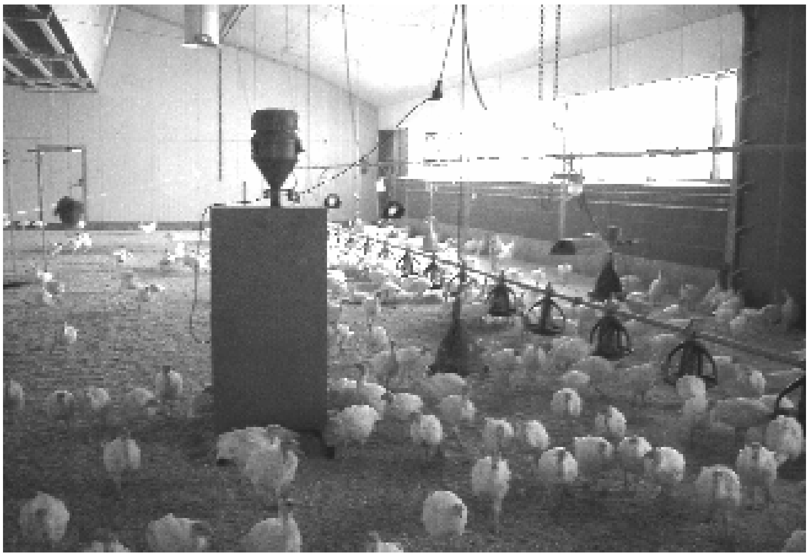

Fig. 1: View into the experimental animal barn housing young turkeys. Structures of feed trufs and round drinkers are recognizable. The high volume sampler for PM10 measurements is to be seen in front.

Round quartz fibre filters (Type QF 20, Schleicher & Schüll, Dassel, Germany) with a diameter of 150 mm were used. The effective sampling area of the filter was only 140 mm wide. This is equivalent to a surface area of 0.0154 m². In order to quantify PM10 the PM10 pre-separator DPM 10/30/00 was used. A calibrated and self-regulating pump providing a basic flow rate of 30 m³/h sucks the sampling air through the filter head. The flow rate can be calibrated under operation conditions (0.516 m³/min).

Parallel to the operation of the PM sampler, 24 h measurements were also carried out with an IOM (Institute of Occupational Medicine, Edinborough, UK) dust sampler (SKC Inc., USA) for inhalable dust particles. The flow rate was 2.5 l/min (SKC Inc., USA). In the IOM sampler glass fibre filters (Whatman, Maidstone, UK) with a diameter of 25 mm were used. (= 0.0005 m² surface area).

Sampled PM masses were gravimetrically determined by using a high resolving balance (Type MC 210 P, Sartorius, Göttingen, Germany). Before weighing was performed, all exposed filter were conditioned for at least 48 hours in an air conditioned room, which was temperature and humiditiy controlled. Non exposed transport filters and control filters in the balance room served as blanks.

The basic measurements were carried out from 28/01/04 to 04/03/2004, which corresponded to a fattening period between day 56 and day 92. During this period the average body weight increased from nearly 5 kg up to 12 kg, which corresponded to nearly 26 kg body weight per m² surface area of the barn.

RESULTS AND DISCUSSION

Because of a considerable lack of knowledge and experience with a new designed aerosol sampler DHA-80 there was a need to elaborate an appropriate sampling period for the PM10 particles. Five different sampling times were tested (sampling period over 24 h, filter change every 12 h, 4 h, 3 h or 2 h). Sampling times of 24 hours were found to be fare too long because the filters were heavily overloaded. It was impossible to weigh these filters without loosing substantial parts of the dust. It turned out that sampling times up to 2 hours delivered reliable results. But even than depending on the activity on the animals, filters could be loaded with a considerable amount of feather parts. However, there is a trend that shorter sampling times guarantee a more homogenous impaction of airborne particles on the filter disks. Figure 2 shows at the left hand side a filter with a lot of loose feather material after a sampling time of 118 minutes with equivals to an air volume of 53.8 m³. On the right hand side a filter is shown after a 3 hours sampling period (82.1 m³). The activity of the animals obviously influences the release of dust and feather parts.

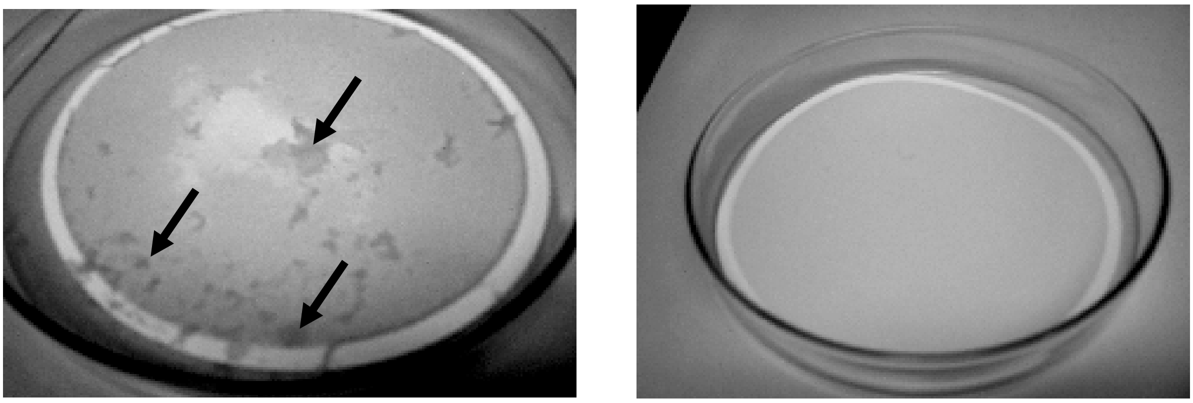

Fig. 2: Dust covered filter disks after exposition in the turkey barn. Left: Loose feather material (arrows) on the filter (sampling time: 2 h; total air volume: 53.8 m³). Right: Smooth layer of PMs of a exposed filter. No visible coarse structured material such as feather material (sampling time: 3 h; total air volume: 82.1 m³).

There is considerable day to day variations of the dust concentrations, which was already confirmed by other investigators [2]. Figure 3 exemplary shows the dust concentrations at seven sampling days between the 17/02/ and 04/03/. The highest dust amounts occurred during the daytime when the light was switched on at 6 a.m. After switch-off of the light at 10 p.m. the PM concentrations decreased considerably, because the activity of the animals declined. It is obvious that there is not a consistent positive correlation between the sampling date, which is equivalent to a mean average weight of the turkeys, and the measured concentration (see below). At the moment there is no clear explanation for the differences between the different days of sampling, but may be explainable by unexpectable confounding factors such as human activity within the building or varying ventilation rates, for instance.

In figure 4 all daily averaged dust concentrations are depicted in relation to the course of the fattening period. There is a clear tendency that the PM10 matters are increasing with the age and the weight of the birds. In other studies increasing body weights of poultry have also caused elevated dust concentrations within the livestock building [3]. Some extreme results around day 60 of the fattening period are possibly due to the working up procedure of the litter as described above. At the very end of the fattening period it looks that the dust concentrations are decreasing. This observation may correspond to the high animal density, when the birds are not able to move or to use their wings to an extent, where considerable dust amounts are released from the animals into the livestock air.

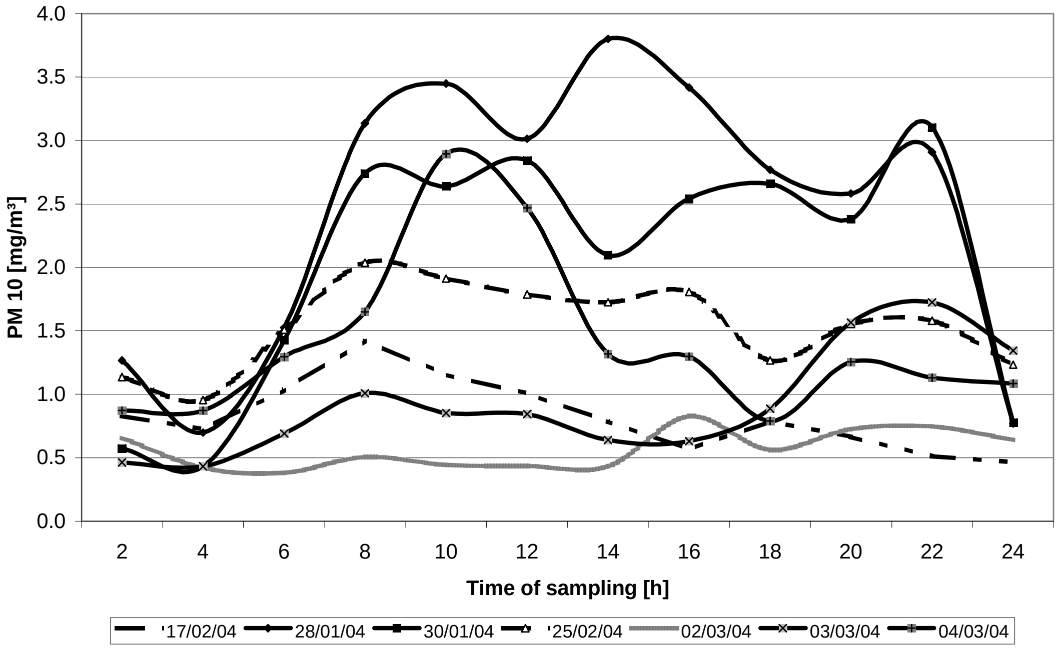

Fig. 3: Examples of daily time courses of PM10 concentrations in the turkey barn.

In Table 1 the PM10 results are compared to the IOM findings between day 56 and 92 of the fatting period. It is obvious that large differences could be observed between the results of the two dust determination techniques. The most amazing result is that PM10 concentrations were always higher than the IOM dust findings, although IOM sampler are able to sample bigger particles (50 % cut-off point of 100 µm) than the PM10 sampler. But nevertheless, in comparison to IOM-related dust the PM10 yields increased by a factor between 3.3 and 9.1. On the other hand the measured IOM dust concentration seems to be reliable, because in other turkey barns comparable dust concentrations were determined [4].

It is not really clear what the reasons are for these great differences. Operational failures can be probably excluded, because there is a significant positive correlation between the values determined with the PM10 and the IOM sampler ($r = 0.65$, $p < 0.02$). Therefore sampling characteristics (impaction forces in the pre-separator, inlet air velocitiy and flow direction etc.) and dust particle properties (density, shape, inertial forces etc.) may cause an oversampling of dust particles in the PM10 sampler. The visible loose feather components may confirm this assumption. Nevertheless, it has to be checked what kind of sampling techniques for PM10 in livestock buildings has to be used to ensure reliable data.

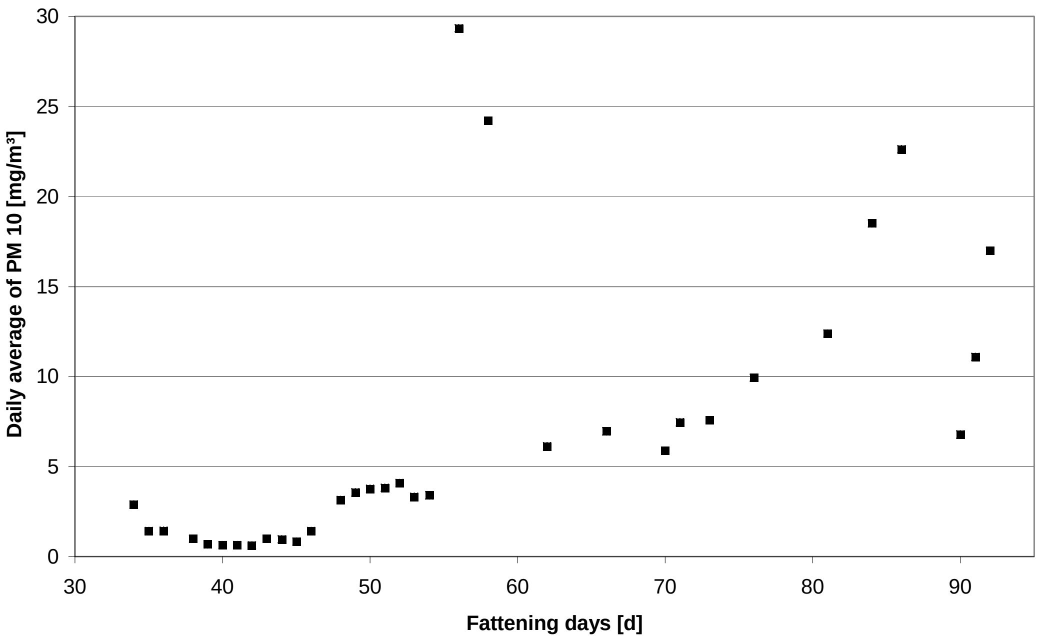

Fig. 4: Concentrations of PM10 on a 24 h average basis. In the figure additional measurements are integrated (06/01/ – 26/01/04). Filter change between 2 and 24 hours.

Table 1: Mean PM10 and IOM dust concentrations per day in the turkey barn.

Sampling day	Fattening day	Digitel DH 80 Filter change every [h]	Digitel DH 80 PM10 [mg/m³]	Digitel DH 80 Sampling volume [m³]	IOM sampler Inhalable dust (ID) [mg/m³]	IOM sampler Sampling volume [m³]	Ratio PM10/ID
28/01/04	56	2	29.3	642	4.3	3.6	6.8
30/01/04	58	2	24.2	646	3.6	3.6	6.8
03/02/04	62	3	6.1	654	1.9	3.6	3.3
07/02/04	66	3	7.0	647	1.5	3.6	4.7
11/02/04	70	4	5.9	657	1.6	3.6	3.8
12/02/04	71	4	7.5	656	2.2	3.6	3.4
14/02/04	73	3	7.6	655	0.8	3.6	9.1
17/02/04	76	2	10.0	655	1.6	3.6	6.3
22/02/04	81	2	12.4	650	1.6	3.6	7.8
27/04/04	86	2	22.6	644	3.1	3.6	7.4
02/03/04	90	2	6.8	663	1.0	3.6	6.6
04/03/04	92	2	17.0	662	2.0	3.6	8.6

CONCLUSIONS

The report presents first results of PM10 measurements in an experimental turkey barn. These measurements were compared to inhalable dust concentrations determined with an IOM sampler. The following conclusions can be generally made:

1. The tested aerosol sampler seems to be suitable to measure PM10 particles in turkey barns.
2. Sampling periods of more than 2 h can overload the filters and lead to erroneous results. Short sampling intervals per filter disk allow also quasi-continuous sampling procedures.
3. In spite of several shortcomings of the presented measurements it seems that turkey house air is an important emitter of PM10 particles.
4. A simple comparison to the measurement of inhalable dust using an IOM sampler shows that there is a relationship between inhalable dust amounts and PM10. But unfortunately, the PM10 yields are considerable higher than the inhalable dust concentrations, although the other way round would be expected. Due to these uncertainties a simple conversion of already available inhalable dust data in the literature into PM10 dust is doubtful.
5. The difficulties when measuring PM10 in a turkey barn indicate that there is an urgent need for more experiences in using appropriate measuring techniques. Animal specific conditions, management factors and also climatic factors inside and outside the barns should be taken more closely into consideration. Measurements outside the turkey barn should help to understand the amount of emissions.

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