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True measuring with „Innova“

Measurement is necessary before valuation. To measure correctly one needs experiences, thinking and a suitable measuring technique. The most important results from real experiences with a photoacoustic device during the last 20 month will be shown in this paper.

There is no reliable emission data from poultry houses, especially for duck farming. The night-day-cycle, especially of the ammonia concentration, the seasons and the animals growing process have a strong influence on the average emission behaviour. There is a difference between measurements taken in spring or summer, or at the beginning or at the end of a fattening cycle. The error and the accident in case of daily or hourly investigations are too high. The actual emission value of one year can not be estimate.

The time interval between two measurements is about 2 minutes.

Ammonia is a notoriously adhesive molecule. The adhesive effect becomes stronger if water molecules are also present. Possible materials for measuring ammonia are stainless steel, gold (on Ni-coated stainless steel), Teflon PTFE (polytetrafluorethylene) and Teflon PFA (perfluoralkoxy) [1]. Stainless steel is unsuitable because water vapour replaces ammonia at certain positions on the metal surface. Gold-coated-material has only a small adhesion for ammonia but it requires an elaborate process that is time-consuming and expensive.

A bottle of ammonia gas can show a defined ammonia concentration, but it is not possible to reproduce the theoretical concentration even by using PTFE/PFA tubes. This state of affairs is very important in case of calibration of an ammonia measuring device. The theoretical values from a calibrated bottle are not provable by practical work. Effects of adhesion appear to be permanent, also by use of dry tubes and nitrogen (N₂). In reality there is certain (air) humidity, we always have to assume a minimum of adhesion of ammonia molecules at the walls. But it is possible to minimize the adhesion by PTFE/PFA components.

Results

The following are the seven most important facts and conclusions which appeared during the last 20 month.

1. „Warm up“

At the beginning of a measurement the measuring device usually displays larger variations in values. These variations decrease with the time and the number of samples. Therefore it is necessary to make sure that the pre-time is long enough.

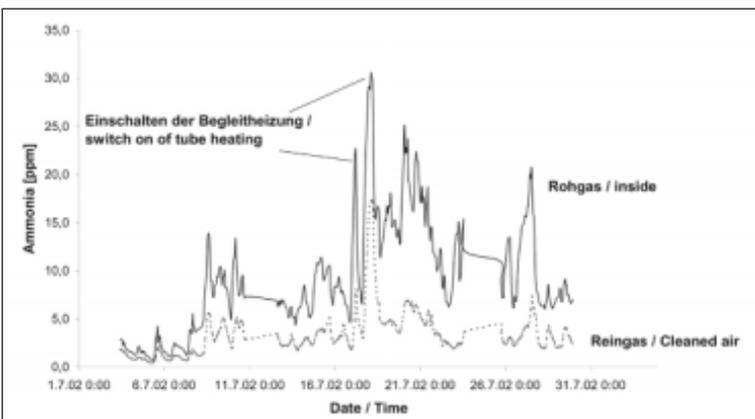
If only the gas monitor 1312 is used the pre-time is about 10 to 30 minutes. Only one measuring point can be investigated. If monitor 1312 and multi-sampler 1309 work together at 12 sampling points the pre-time is between three and four hours. Measurements in kind of 1312 and 1309 over a time period of some hours are useless.

Methods and material

A suitable device for the ammonia concentration should be measured in the range between 1 ppb and 100 ppm. The time interval between two samples should be shorter than 5 minutes. Then a measurement is taken continuously. The use of the photo acoustic gas monitor 1312 from the company Innova Airtech Instruments (former Brüel & Kjær, Denmark) meets all requirements. The monitor is used by a large number of agricultural universities, research centres and federal institutes for more than 10 years. All these organisations mainly measure in animal stables. In that way the monitor 1312 can be considered as „standardized“. But the 1312 is also used by the industry, to calibrate other measuring devices.

The gas monitor 1312 can work together with the multi-sampler 1309. The 1309 can regulate the sampling from 12 measuring points, for example for ammonia, methane, dinitrogen oxide, carbon dioxide and water.

Fig. 1: Mean ammonia concentration in a duck fattening house



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Literature

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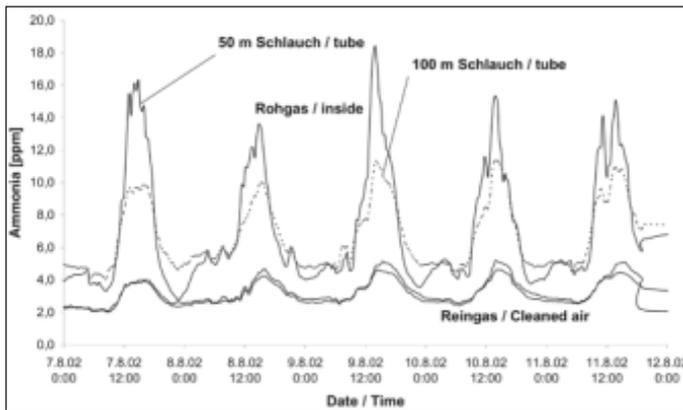


Fig. 2: Effect of hose length on proofing ammonia

2. Starting value

The first value of an air measurement is the highest and so the most unsuitable. One reason is the use of (long) tubes. The following values from the same measuring point (equal ammonia concentration) are lower. Beginning from the 3rd repetition the decrease becomes smaller and disappears by ten repetitions.

3. Repetition

This fact is based on prior information. Normally the sampling points will be measured alternately, for example 1, 2, 3 and 4 in case of four points. The cycle goes on up to the cancellation or the end of a determined interval. To get a realistic value for one sampling point it is necessary to make some repetition. The correct number of repetitions is ten because the decreasing process has disappeared.

Indeed, the software for the monitor 1312 and the multi-sampler 1309 is limited by 40 repetitions. In case of 12 sampling points there are only three repetitions possible ($12 \cdot 3 = 36$). That is not the optimum but better than a single measurement.

During the described investigations we misplaced our own first and second results. We only considered the 3rd value. On the one hand this is a „destruction of data“ by 66%, on the other hand we get 33% much more realistic values to calculate the emission mass flow.

4. Tube length

The internal pump of the 1312 can carry the sampled air by 3 l/min through PTFE tubes with a diameter of 4 mm. Therefore it needs ten seconds. In that time 1 m tube content can be detected. The minimum of tube length we used was 20 m, the maximum 100 m. To obtain a representative sample an external pump was necessary. The internal pump can carry the sampled air by 7 l/min (= 30 cm/s). The advantage: next (new) air sample can be sucked in during detection of the old sample (2 min) in the monitor 1312. In the 2 minute

period of time an air sample can be sucked in through a tube length of 36 m. That guarantees that the calculated ammonia concentration really is actually based on stable air.

As written above we used tubes longer than 36 m. Using this method the pump power was too low, and the concentration values were from inside the tube. But considering Fact 3 (repetition of three times at one measuring point) it is absolutely clear that the 3rd value can be used.

It is very important to know that the measured concentrations of ammonia are too low and those of dinitrogen oxide and methane are unreliable if a tube of more than 50 m length was used. In case of 12 tubes (multi-sampler 1309) and a repetition of three times an air sample must stand about one hour in the tube. There must have been changes of air in methane and dinitrogen oxide in long tubes in this time. The probable reasons have not been solved yet.

5. Heating

A tube heating prevents vapour in the sampling tubes. The heating we use is infinitely variable between 1 and 100°C. It doesn't matter if the heating temperature is 10 or 20°C. But the heating temperature must be higher than the sample temperature to prevent vapour inside. It may be important to increase the heating temperature in the summer.

The decisive factor is the pre-heating of the sampling tubes before measuring. If the heating is switched on during the measuring process the ammonia concentration increases suddenly. This effect only appears at the beginning of heating process and becomes normal after eight hours. In case of one-day-measurements the tube heating must be switched on the day before.

6. Filter

To keep the monitor clean from dust, dirt etc. we use one-way-filter. Monthly changing of the filters is enough because the level of dirtiness did not affect the measured values.

7. Reliability

The monitor 1312 and the multi-sampler 1309 were extremely reliable. However, nobody denies the fact that basic conditions like permanent electricity must be guaranteed and interferences of unauthorized persons must be prevented.

Conclusion

Considering the results obtained the following points should be taken into account:

For one measuring point:

- switch on of tube heating the day before
- „warm up“ of 30 minutes is necessary without heating
- reject the first ten concentration values
- tube length up to 150 m

For multiple measuring:

- switch on of tube heating the day before
- „warm up“ of four hours is necessary without heating
- repetition (of three times)
- reject the first and second concentration values
- tube length up to 50 m