Monitoring Odour Emissions from Agriculture - Use of Chemical Sensor Arrays

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For a wide variety of reasons, odour is causing more and more problems because it disturbs residents who live close to farms. Due to the growing sensitivity of the population, the measurement of undesirable odours has become a problem that may no longer be neglected.
In this contribution, results of a comparison of different ventilation systems gained with a multisensor array are documented. The big advantage of multisensor array measurements over olfactometry lies in the continuous registration of measurement values in contrast to the few random samples taken during olfactometric measurements.

Keywords
Emission, odour, multisensor-array, monitoring

Introduction

So far, the emissivity of different animal husbandry systems has generally been measured using climate-relevant trace gases as indicators. Due to a lack of measuring instruments, odours have usually not been integrated into an evaluation. In this contribution, the results of a monitoring of odour emissions from different stall systems with multisensor arrays are published.

Material and Methods

Olfactometry is currently state of the art for the measurement of air pollution in odour- and effect-related units. The VDI 3881 guideline provides more detailed regulations concerning this field [1-4].
The design and the functional principle of the multisensor array were explained in detail in part 1 of this series of publications [5, 6]. The described multisensor array, which is designed for laboratory measurements, was extended for measurements near stalls. Trials have shown that the heat release of the instrument is sufficient to prevent temperatures from dropping below the operating temperature if the capsule is temperature-insulated and freely exposable to the weather. In order to facilitate operational testing, the capsule was fitted with an opening for the operating units. This allows an examination as well as the necessary restarting of the measurements during a longer measurement period without having to open the capsule.
However, overheating caused by summer temperatures and especially by solar radiation turned out to be problematic. For this reason, the capsule had to be equipped with a controlled refrigerating unit. The temperature in the interior of the capsule is set at 25°C +/- 2°C. This enables the sensors to be kept at the necessary operating temperature. To secure the data quality, a moisturizing unit was integrated into the encapsulated and thermostatted chamber.
The trials were conducted on one farm in two compartments of the same fattening pig stall. The samples were taken from the exhaust air channels of the two warm stall compartments. The difference was in the ventilation systems: the principle of overfloor suction was applied in one of the two compartments and underfloor suction in the other one. On 13/09/99, while the 8 day trial (from 08/09/99 until 15/09/99) was in progress, ventilation in the compartment which had been ventilated through overfloor suction until then was changed to underfloor suction, as in the other compartment.
An illustration of the stall was already shown in the previous issue in part 2 [7] of this publication series. When determining the odorant concentration, it must be taken into account that the average weight of the pigs in the individual compartments (compartment 1 u-floor ca. 50 kg/pig, corresponding to 19 livestock units (LU); compartment 2 o-floor ca. 100 kg/pig, corresponding to 41 LU) varied.

Monitoring in Fattening Pig Husbandry

Parallel to the continuous measurements with the multisensor array, olfactometric measurements were also taken. The results of these measurements are shown in **figure 1**. Over the entire period, a difference in the odorant concentrations of the two stall compartments is recognizable. Over the trial period, 10 samples from each stall compartment were measured. On average, two samples per day were

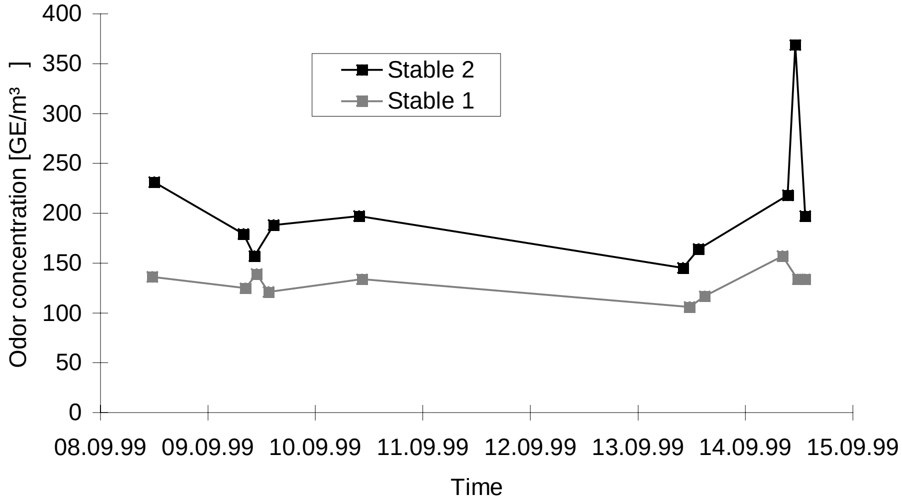

Figure 1: Olfactometric odour measurements in two stall compartments of a pig fattening farm

analyzed. A lack of samples during the period from 11/09/99 until 13/09/99 is obvious. This very clearly shows an important problem of olfactometry. Employing a representative group of test persons at the weekend causes very high personnel costs. In addition, there is the problem of the dependence of the measurement value on the daily condition of the test person(s). This also explains the unusual value at the end of the measurements. The thus established mean odorant concentration in stall compartment 2 amounted to 204.5 odour units (OU)/m^3. In the exhaust air channel of stall compartment 1, which had the smaller pigs, the concentration was slightly lower at 130.3 OU/m^3.

The measurements with the multisensor array were able to furnish a set of data every 20 minutes. Hence, a measurement point from a stall compartment was provided once every 40 minutes. In order to be able to show the temporal course, the 18-dimensional information of the multisensor array is reduced to one value per measurement. An initial approach, which was already used in the literature [8], is adding the sensor deflections. Using this method, one obtains a sensor sum signal, which, however, does not contain any weighting of individual sensors. In the future, this weighting will certainly become necessary. An initial approach will be demonstrated here. Using this method, a monitoring was able to be carried out. The results are shown in **figure 2** below. Similar to the olfactometric establishment of concentration, the values of stall compartment 2 are higher than those of stall compartment 1, which had the smaller pigs. The change to a different ventilation system on 13/09/99 caused little alteration in the sensor deflections.

The data of the olfactometry and the sensor measurements were joined. The olfactometric measuring points for which there are simultaneous multisensor array measurements then serve as the basis for the calibration of the multisensor array.

According to the literature [8], the correlation between the olfactometric odour units and the sensor signals is established using the sensor sum signal (sum of the maximum deflections of the 18 sensors). The data collected during this project yield the calibration line shown in **figure 3** for the odorant concentration as a function of the sensor sum signal.

Using this calibration, the continuously registered sensor data can be converted into odorant concentrations. During these measurements, a measurement of stall air from one of the two compartments was taken every 20 minutes over a period of 8 days. Hence, data from a stall compartment were collected in time intervals of 40 minutes. This allowed quantitative-continuous monitoring of the two stall compartments to be carried out. Over the entire period, the odour monitoring shown in **figure 4** yields a higher concentration in stall compartment 2, which had the larger pigs. These results are analogous to the olfactometric data. However, through the continuous collection of data using the multisensor array a daily course becomes obvious, especially for the smaller animals. This manifests itself in an increase in the odorant concentration in the morning hours and a reduction during the night hours.

Due to these lower nightly values, which were not registered during the olfactometric measurements, the mean value of the sensor measurements is slightly lower as compared with olfactometry. A summary of these values is shown in **table 1**.

In order to take the different animal masses into account, a comparison of the emission rates of the two stall compartments is necessary. The problems caused by a possibly different metabolic activity of the pigs at different weight- and age stages will not be discussed here. Moreover, definitive statements regarding the two ventilation systems cannot be given, which is also due to the short observation period.

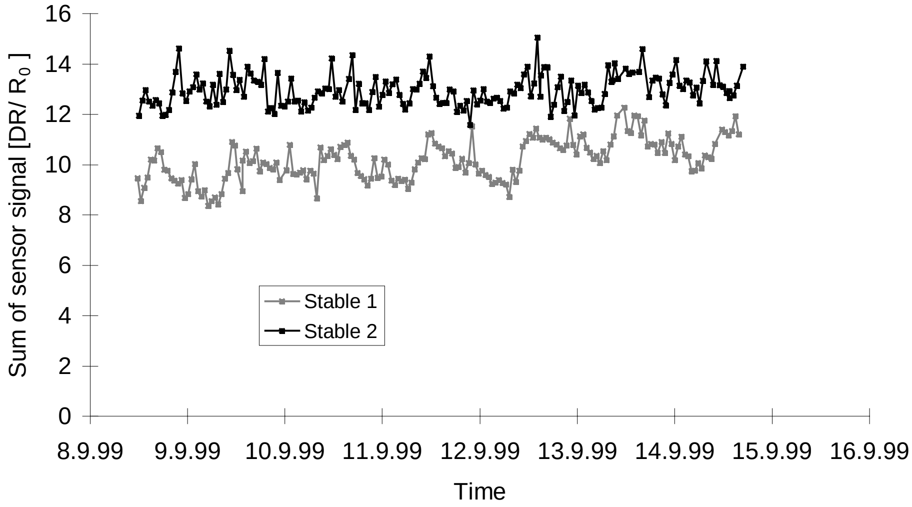

Figure 2: Measurements in two stall compartments of a pig fattening farm using the multisensor array

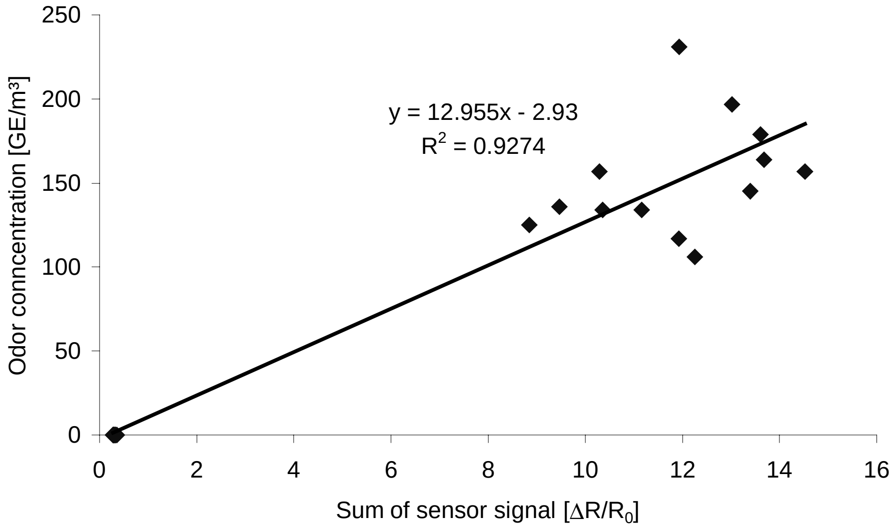

Figure 3: Calibration line of the odorant concentration as a function of the sensor sum signal

Table 1: Comparison of the mean odorant concentration in two compartments of a stall for fattening pigs using olfactometry and the multisensor array

Stall compartment	Animal mass (livestock units)	Odorant concentration (odour units/m^3) olfactometric	Odorant concentration (odour units/m^3) multisensor array
1	19	130.3	128.89
2	41	204.5	165.23

In **table 2** below, the data are again summarized. In the third line, the values of the two stall compartments were correlated. Here an attempt was made to find the reason for the alteration from the concentration measurements, where the values for stall compartment 2 were higher, to the emission rates, which were higher for compartment 1. The emission rate was calculated based on the odorant concentration multiplied by the volume flow divided by the animal mass. As is apparent from the third line of this table, the different animal weights have the greatest influence, which overlays that of both different ventilation and different odorant concentration.

As can be seen from the two diagrams in **figures** 4 and **5**, the measurements taken here did not show any change in the odorant concentration or the emission rates caused by the change of the ventilation system on 13/09/99. Long-term measurements for a definitive assessment of the ventilation systems are currently being carried out. These more precise studies over all seasons take further influencing factors such as different ventilation rates and increase in animal mass into account. Only then can the different air conduction systems be evaluated with regard to odour emissions.

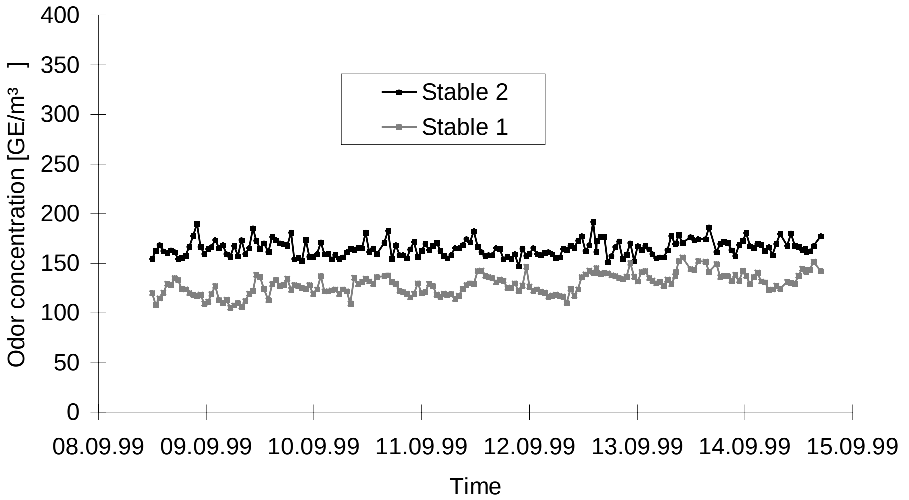

Figure 4: Odour monitoring in two stall compartments of a pig fattening farm using a multisensor-array comparison of the odorant concentrations

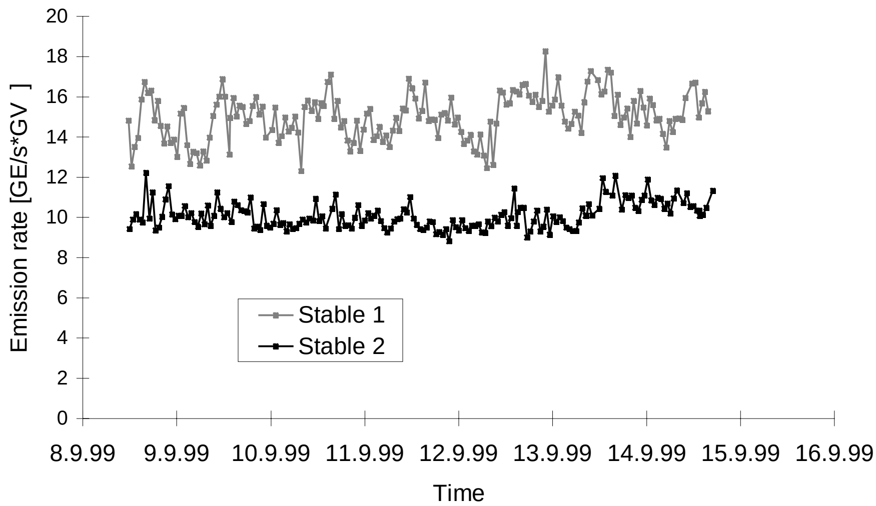

Figure 5: Odour monitoring in two stall compartments of a pig fattening farm using a multisensor-array comparison of the emission rates

Table 2: Comparison of the two stall compartments

Stall compart-ment	Odorant concentration olfactometric [OU/m^3]	Odorant concentration MSA [OU/m^3]	Ventilation rate [m³/h]	Animal weight [LU]
1	130.3	128.89	7690	19
2	204.5	165.23	8897	41
2/1	1.56	1.28	1.16	2.16

Conclusions

The results documented here show that it was possible to assess odours from agriculture with the aid of the multisensor array. In one monitoring, data from several measuring points were able to be collected simultaneously. The data of the 18-dimensional sensor measurements were reduced by adding up all sensor values. This sensor sum signal was then linearly correlated with the olfactometric measurements which were taken simultaneously. This opened up the possibility of observing the daily course of odour in small time intervals and also provided the chance to monitor odours continuously over a period of several weeks. The big advantage over olfactometry resides in objectivity, i.e. independence of the daily condition of the test persons. This is mainly achieved by employing a well-trained group of test persons for the few olfactometric measurements which are necessary for the calibration of the multisensor array and which will certainly diminish in number as the tests progress. This allows for both a comparison of husbandry systems and odour monitoring. Such monitoring can also register nuisance outside the usual working hours.

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