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Does the Choice of Olfactometric Laboratory Affect the Efficiency of Odour Abatement Technologies?

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In 2010 during a test of a biological air cleaner 16 samples in triplicates were collected before and after the air cleaner over 8 weeks and analysed within 30 hours at two Danish laboratories and one German laboratory. There was a significant difference between the results from the three laboratories. The mean values of odour concentration from the laboratory with the highest results were up to 27 times higher than those from the laboratory with the lowest results (n = 16). Besides the discrepancy between the results from the laboratories, the odour removal efficiency of the air cleaner varied from 16 % to 80 %, indicating that the result of the test of the air cleaner largely depends on the choice of laboratory. One of the main groups of odorants from pig production is the volatile organic compounds containing sulphur, especially hydrogen sulphide and methanethiol, which are considered to be some of the most important and potent odorants. Hydrogen sulphide was always measured when odour samples were collected. Analytical results from one of the Danish laboratories and the German laboratory obtained in 2011 showed that hydrogen sulphide contributes to odour concentration to a different degree in the two laboratories. Both laboratories comply with CEN EN 13725:2003 (CEN EN 13725, 2003) standard and use the same kind of olfactometer.

1. Introduction

The Danish Pig Research Centre (PRC) has measuring odour from Danish pig units since 2002. These measurements have formed the basis of the national Danish standard figures on odour emissions from pig units, national regulations on acceptable odour levels with regard to neighbours to pig units, and documentation of the efficiency of odour abatement technologies for livestock production accepted by the Danish Environmental Protection Agency. In 2010, common Danish, Dutch and German protocols for testing and verifying environmental technology for agricultural production (VERA, 2010) was launched. The purpose of the VERA (2010) protocols is to promote an international market for environmental technologies for agricultural production, and one of the central issues is that the authorities in one country should accept documentation for the efficiency of environmental technology tested in one of the other countries. To document an odour abatement technology (e.g. air cleaning or slurry treatment systems), the use of any olfactometric laboratories should be possible as long as they comply with the same standard (CEN EN 13725, 2003). For several years, PRC has routinely tested Danish accredited olfactometric laboratories and has not found any significant difference between the laboratories. As a result of the VERA (2010) protocols, PRC has performed several round robin tests in which one German olfactometric laboratory was compared with one or two of the Danish laboratories. This was done to determine whether there would be any significant difference between the results from

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the laboratories in Denmark and Germany used for documentation of odour abatement technology for agricultural production.

2. Method and materials

2.1 Sampling points

Odour sampling was carried out at pig facilities. Air from the pig units was collected in the ventilation stack either immediately before or immediately after the ventilation fan. When sampling air from air cleaners, the samples were collected either between the filters in the air cleaner or immediately after the last filter.

2.2 Odour sampling

All air samples taken for olfactometric analysis were collected in 30 L bags made of Nalophan (Polyethylene terephtalate, PET) using the lung principle. The bags were connected to the sampling point by a Teflon (Polytetrafluoroethylene, PTFE) tube (8 mm i.d.). Identical samples for analysis on different laboratories were filled simultaneously using parallel tubes of the same length to connect the sample point to the bags. On each day, two samples were collected at each sampling point for each laboratory. The sampling time was 30 min. After sampling, the bags were protected from light and physical exposure in black plastic bags and cardboard boxes during transportation to the laboratories for analysis the following day within 30 h of sampling. This timespan was chosen for practical reasons and lies within the standard, but it is possible that it could have affected the samples (e.g. Guillot and Beghi, 2008; Hansen et al., 2011). Temperature and relative humidity were measured at the sampling point either during the sampling or immediately after the sampling.

2.3 Hydrogen sulphide

Hydrogen sulphide (H_2S) was measured at the same sampling points either simultaneously or immediately after the odour sampling. Measurements were performed using a Jerome 631-XE Hydrogen Sulphide analyser (Arizona Instruments LLC, Chandler, AZ).

2.4 Round robin tests

During the test of the odour reduction efficiency of a biological air cleaner a round robin test was performed by shipping odour samples to three laboratories in Denmark and Germany in the summer of 2010. During an eight-week period, a total 96 samples (32 samples in triplicates) were collected and analysed.

Additional round robin tests between one of the Danish laboratories and the German laboratory were performed in 2011 when testing two kinds of environmental technologies for pig housing systems. In the first trial, which focused on manure handling, a total of 46 samples in duplicates were shipped for analysis at the two laboratories over a six-week period. In the other trial, which focused on pit ventilation, 30 samples in duplicates were shipped to the two laboratories over a five-week period.

2.5 Statistics

The logarithmically transformed odour concentrations were analysed by an analysis of variance using the MIXED procedure in SAS (2009).

3. Results and Discussion

3.1 Round robin tests

Results from the round robin test performed during the test of a biological air cleaner in the summer of 2010 are shown in Table 1. There was a significant difference between the results from the three laboratories. The mean values of odour concentration from the laboratory with the highest results were up to 27 times higher than those from the laboratory with the lowest results (n=16). Besides this divergence between the analysis from the laboratories, the odour reducing efficiency of the air cleaner varied from 16 % to 80 % between the laboratories (Table 1), indicating that the result of the test of the air cleaner largely depends on the choice of laboratory.

Table 1: Average odour concentrations and cleaning efficiency of a biological air-cleaner. Numbers in brackets are 95 % confidence interval, n=16.

	Before (OU_E/m^3)	After (OU_E/m^3)	Reduction (%)
Lab 1 – German	230 (170-310)	45*** (33-62)	80
Lab 2 - Danish	490 (350-690)	400(*) (290-570)	18
Lab 3 - Danish	1,400 (1,100-1,900)	1,200NS (930-1,600)	16

*** Statistically significant difference, P<0.001 relative to the odour concentration before the air cleaner.
(*) Tendency towards a statistically significant difference, P<0.10.
NS No statistically significant difference. Data from Riis (2012).

In the manure handling test, there was no significant difference between the analysis from the Danish laboratory and the German laboratory (Table 2). However, there was a distinct daily variation between the results from the two laboratories (Figure 1). On the June 14 there was hardly any difference between the results from Lab 1, whereas Lab 2 shows result from 450 to 900 OU_E/m^3. The opposite situation was observed on June 28. On three of the six days the correlation between the results from the two laboratories shows a negative slope indication no correlation between the data.

Table 2: Average odour concentrations from a trial on manure handling, n=24.

	Control (OU_E/m^3)	Case (OU_E/m^3)
Lab 1 – German	290	260
Lab 2 – Danish	530	560

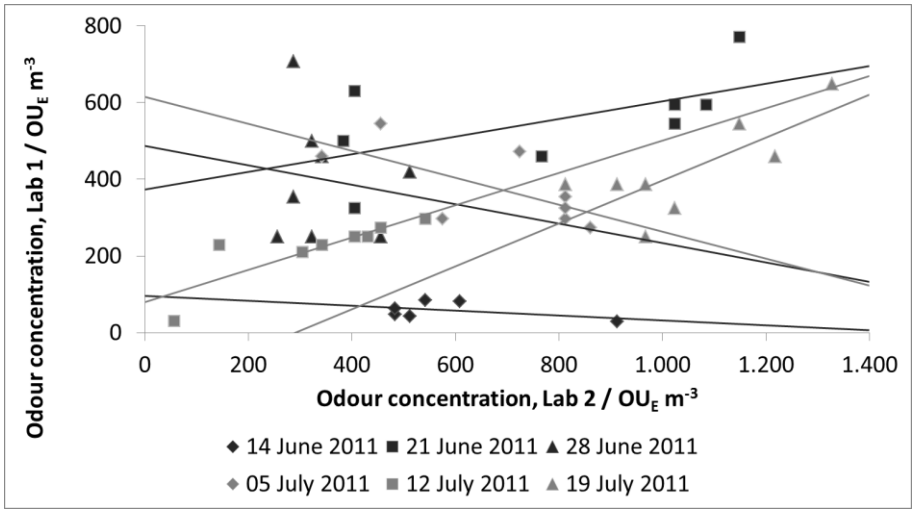

Figure 1: Daily comparative measurements of odour (n=8) between laboratory 1 and 2 on six days from a trial on manure handling. The lines indicate the correlations between the results from the two laboratories on each day.

In the pit ventilation test, where the effect of pit ventilation on collecting a large proportion of the total odour in the pit ventilation is indicated by the ratio between the odour concentrations in the air from pit ventilation and roof ventilation, the choice of laboratory once again influenced the result of a test (Table 3). Based on the results from the German laboratory, this ratio was 1.9, while the ratio based on the Danish result was 3.4, indicating a more positive effect of pit ventilation on air quality in the pig unit.

Table 3: Average odour concentrations in the air from pit ventilation and roof ventilation in a pig production unit, n=12. Pit-roof ratio indicates the efficiency of the pit ventilation.

	Pit ventilation (OU_E/m^3)	Roof ventilation (OU_E/m^3)	Pit-Roof ratio
Lab 1 – German	480	250	1.9
Lab 2 - Danish	2,100	620	3.4

3.2 The effect of sulphur containing volatile compounds on odour

Correlations between H_2S and odour concentrations performed on the results from the two laboratories, and H_2S measured during the odour sampling are shown in Figure 2. The upper diagram 2a clearly shows that H_2S contributes to the odour concentration to a different degree in the two laboratories. If H_2S is one of the dominant odorant in the air from pig facilities, the slope of the graph should be significantly different from zero; on the other hand, if H_2S does not contribute to the odour, the slope of the graph should be zero. This indicates that the sensitivity for H_2S is high in the Danish laboratory and low in the German laboratory. The lower diagram 2b shows the same pattern; however the correlation it not that clear compared to 2a. This difference is probably due to the lower concentration levels in 2b.

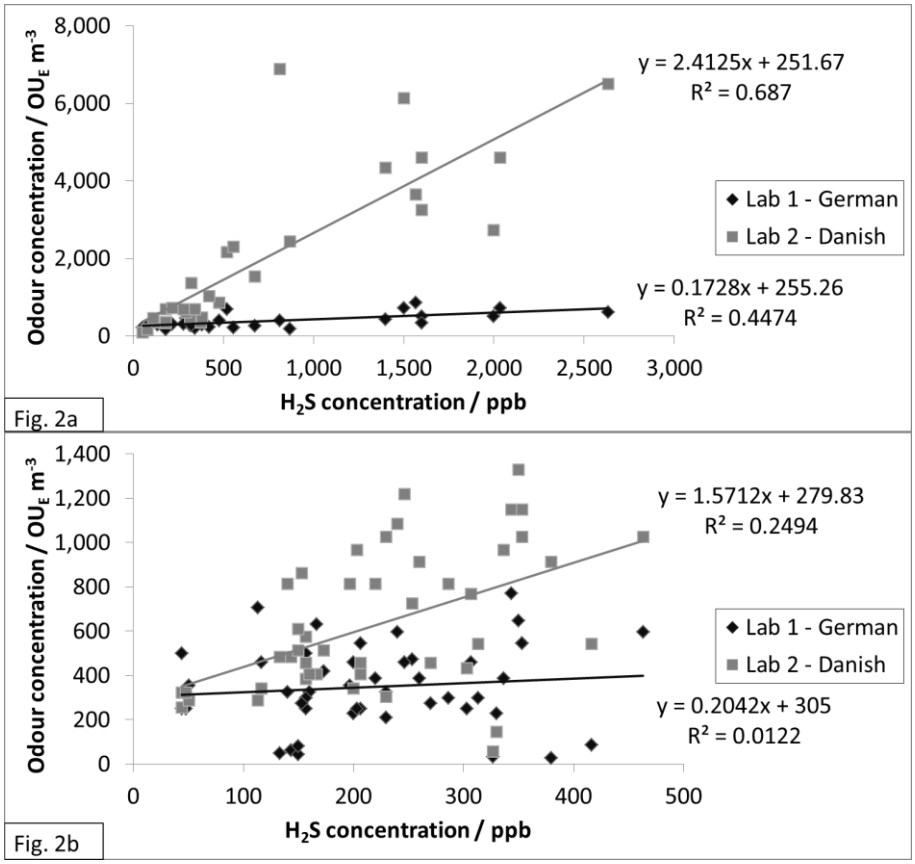

Figure 2: Correlation between odour measured at two laboratories and H_2S concentrations measured during sampling of odour. The upper diagram a) shows data from the trial on pit ventilation, the lower diagram b) from the trial on manure handling.

It is generally accepted and documented that volatile sulphur compounds, in particular H_2S, contribute significantly to odour, not only from animal production units, but also from sewers and wastewater

treatment facilities where anoxic conditions prevail. The odour activity values (OAV), the ratio between the concentration and the odour threshold value (OTV) of an odorant, indicates in which degree the odorant contributed to the total odour concentration. Hansen et al. (2012) measured selected odorants in the ventilation air from a pig production unit using Proton-Transfer-Reaction Mass Spectrometry (PTR-MS) before and after the biological air cleaner mentioned above. Based on these data OAV for each odorant can be calculated (Table 4). Assuming that the OAVs have an additive effect, it can be seen that H_2S and methanethiol are the most important odorants in the ventilation air contributing with 33 % and 31 % respectively of the relative OAV before the air cleaner, and 22 % and 68 % respectively of the relative OAV after the air cleaner. It is the same two odorants that have the lowest degree of removal in the air cleaner.

Table 4: Odour activity value (OAV) for 17 selected odorants measured before and after a biological air cleaner located at a pig production unit. Based on data from Hansen et al. (2012).

	Odorant concentration (ppb)		OTV (ppb)	OAV		Odorant contribution to total OAV (%)	
	Before air cleaner	After air cleaner		Before air cleaner	After air cleaner	Before air cleaner	After air cleaner
Hydrogen sulphide	353	86	1.9	186	45	33	22
Acetaldehyde	6,8	0.5	38	0.2	0	0	0
Methanethiol	12	10	0.07	171	143	31	68
Acetone	7,1	0.8	13,000	0	0	0	0
Trimethylamine	12	0.8	2.1	5.7	0.4	1.0	0.2
Acetic acid	314	1.2	234	1.3	0	0.2	0
Dimethyl sulphide	3	2.7	4.1	0.7	0.7	0.1	0.3
2-butanone	3,3	0.6	4,500	0	0	0	0
Propanoic acid	67	0.5	25	2.7	0	0.5	0
2,3-butanedione	1,2	0.2	0.01	120	20	22	9.5
Butanoic acid	42	0.3	1.8	23	0.2	4.2	0.1
Phenol+dimethyl disulfide	2	0.2	54	0	0	0	0
C5 carboxylic acids	11	0.2	1.4	7.9	0	1.4	0.1
4-methylphenol	9.5	0.2	0.3	32	0.7	5.7	0.3
Indole	0.7	-	0.4	1.8	-	0.3	-
4-ethylphenol	1.2	-	1.3	0.9	-	0.2	-
Dimethyl trisulfide	0.1	-	1.7	0.1	-	0	-
3-methylindole	0.4	-	0.09	4.4	-	0.8	-

3.3 Difference between the olfactometric laboratories

Both laboratories comply with the CEN EN 13725:2003 standard and use the same kind of olfactometer from Ecoma with the Yes-No approach and there are no known differences in the working practices between the two laboratories. The only difference between the two laboratories is the way in which the panellists are selected. Both laboratories use n-butanol following the standard; however, the German laboratory has also used H_2S according to the German directive GIRL (2009). It is not the purpose of this paper to draw any conclusions on whether it is reasonable or not to carry out the additional selection of panellists based on the sensitivity of H_2S. However, the different approaches used in the two laboratories can explain why a difference in both odour concentration and environmental effect of the technologies was observed.

4. Conclusion

It is illustrated that the documented effect of odour abatement technologies for animal production largely depends on the choice of olfactometric laboratory. The data indicate that the difference between the laboratories largely depends on the sensitivity of the panellists in the laboratories towards H_2S.

Finally, it has previously been estimated that H_2S and methanethiol contribute significantly to the odour from pig production.

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