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# Development of an Olfactometric Measuring Facility according to CEN EN 13725 and to Generate up to Date Odour Concentrations from Animal Houses in Flanders

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Intensive livestock farming is a major production system in Flemish agriculture, with nearly 6 million pigs and 28 million poultry units. Over the last five years, there's a tendency towards fewer, but larger farms, resulting in about the same end production values. This evolution can pose both acute and long term problems in a region with a high population density like Flanders. The most recent odour research in Flanders is documented by Ghent University (De Bruyn et al., 2001; Van Langenhove and De Bruyn, 2001; Van Langenhove and Defoer, 2002). Since 2004, it became obligatory in Flanders to build low ammonia emission housing systems. Until now, the impact of this important evolution is not investigated with regard to indoor odour concentration and emission behavior. This lack of knowledge results today in a problematic situation for the livestock industry, whereby the exploitation of extensive animal farming can be hindered. Therefore, ILVO started some odour focused research projects in collaboration with Ghent University.
In 2011, ILVO started with the development of an olfactometric measuring facility in order to generate up to date odour concentration and emission levels from animal houses in Flanders. The "Odour Lab" at ILVO is built to fully comply with the European and Belgian standard for olfactometry, CEN EN 13725 (2003) and NBN EN 13725 (2003). Since November 2011, the odour panel selection procedure was started. Up to now, from a test population of 43 candidates, 30 persons performed n-butanol tests on 3 nonconsecutive days. From these 30 persons, 11 persons were found qualified for both criteria of CEN; 16 persons failed for either one criterion and 3 persons failed for both criteria. So both criteria of the European Standard proved to be bottlenecks. It could also be concluded that sustaining a workable number of panel members, makes the panel selection procedure a continuous and dynamic process.
A first sampling and measurement campaign was started in January 2012. Odour sampling was done in both a traditional and a low ammonia emission compartment of a pig fattening facility in Diksmuide, Belgium. During the sampling campaign, both compartments were cleaned intensively with water and disinfectant. The first olfactometric results of this campaign give some preliminary indications of present indoor odour concentrations. They also suggest possible effects of compartment cleaning. At present, no clear differences could be noted when comparing the results from the traditional and the low ammonia emission compartment. These first odour measurements also indicate some possibilities to further optimize and validate the sampling and measurement protocols.

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## 1. Introduction

Brattoli et al. (2001) mentioned that the sense of smell allows people to perceive the presence of some chemicals in the ambient air and that olfaction has developed into a significant tool in different fields as illness detection, quality assessment in food and beverage industry. Odour is also more often seen as an environmental concern, as more attention is paid to air quality in general, and with a rising amount of odour related complaints, coming forth of the personal sense of smell, in particular.

Schulz and Van Harreveld (1996) quoted that olfactometry has been investigated and applied since the 1890s. From 1970s onward, olfactometry is used in an environmental context. Dynamic olfactometry is now the standardized European method for the determination of odour concentrations (Brattoli et al., 2011). The method is fully described in the European standard CEN EN 13725 and the Belgian standard NBN EN 13725 and pays much attention to the panel selection procedure to provide a reliable sensor for odour measurements.

In Flanders (Belgium), the most recent, published olfactometric odour concentrations from intensive livestock, were achieved by Van Langenhove and Defoer (2002). Table 1 gives an overview of the concentration ranges over different seasons presented in this study. These data are all measured at conventional pig fattening facilities.

*Table 1: Odour concentrations for fattening pigs determined by Van Langenhove and Defoer (2002).*

| Season | Minimum Odour Concentration ($ou_E/m^3$) | Maximum Odour Concentration ($ou_E/m^3$) |
|---|---|---|
| Winter | 737 | 13,109 |
| Spring | 1,456 | 13,361 |
| Summer | 553 | 10,058 |
| Fall | 899 | 9,468 |

For Flanders, there are no indoor odour concentration data available for low ammonia emission pig houses. Dutch research suggests that such pig houses can have lower odour emissions, compared to conventional pig houses (Verdoes and Ogink, 1997; Ogink and Koerkamp, 2001). An important factor in this, is of course pig house management. De Bruyn et al. (2001) indicated that frequent manure removal and cleaning can lower odour emissions. Lim et al. (2004) showed that daily flushing of manure channels reduces odour emissions with 34 to 41 %. Jacobson et al. (2001) states that the potential for odour production can be reduced by instituting good housecleaning and management.

## 2. Material and methods

### 2.1 Panel selection tests

In October 2011, an odour lab was built at the Technology and Food Science Unit of the Institute of Agricultural and Fisheries Research (ILVO, Merelbeke). This olfactometric laboratory is specifically established to perform research on odour emissions from intensive livestock. The installed olfactometer is a TO8 instrument from the Odournet TO-series (Germany), with four panel member places. The ‘yes/no’ method is used for the determination of the odour detection threshold (CEN EN 13725). The reference gas, n-butanol in nitrogen, has a concentration of 59.22 ± 2.96 ppmv (Westfalen AG, Germany).

In November 2011 the panel selection procedure was started and conducted according to CEN EN 13725. Compliance with the following panel selection criteria was tested:

- Criterion 1: The geometric mean of the individual threshold estimates ($\bar{y}_{ITE}$), expressed in mass concentration units of the reference gas. Lower limit value: 20 ppb; Upper limit value: 80 ppb for n-butanol.
- Criterion 2: The antilog of the standard deviation ($10^{s_{ITE}}$), calculated from the logarithms ($log_{10}$) of the individual threshold estimates, expressed in mass concentration units of the reference gas. Upper limit value: 2.3.

The first obtained individual threshold estimate of a person was always omitted for the evaluation, since a panel candidate needs training.

Panel members were also restricted to make less than 20 % of blank mistakes. Until present, 43 persons performed different panel selection tests on nonconsecutive days, of which 30 persons performed three such selection tests as prescribed by CEN (2003). Each measuring session had a duration of 40 up to 90 minutes. During each session 6 to 10 n-butanol thresholds were determined.

### 2.2 Sampling campaign in Diksmuide

In January 2012, an odour sampling campaign was started at a pig fattening farm in Diksmuide (Flanders, Belgium). The farm has both traditional and low ammonia emission pig house compartments. All compartments are mechanically ventilated (door ventilation), with separate ventilation fans per compartment. The traditional housing system is equipped with fully slatted floors. The low ammonia emission system is based on a reduced emission surface with sloped walls in the manure pit. All compartments were intensively cleaned with water and disinfectant between January 16$^{th}$ and January 23$^{th}$.

Odour samples were taken on several days from January until March 2012, in both one traditional and one low ammonia emission compartment. Before cleaning, the sampled traditional and low ammonia emission compartment contained 52 and 67 fattening pigs respectively. After cleaning, the compartments were filled with 59 and 69 fattening pigs, respectively.

Sampling was always done with closed doors. All samples were taken simultaneously in duplicate and between 9:20 AM and 13:20 PM. The sampling duration was 15 minutes. Each sample was collected in a 10 L Nalophane bag, placed within a sampling cylinder. Sampling was done with the lung principle along a Teflon tube of 1 meter 30 which was flushed before sampling with compartment air. The sampling height was 20 cm beneath the ventilation duct.

The samples were analyzed within 30 hours after sampling at the olfactometer by the qualified panel members and candidates with good performance during their first panel selection sessions. Each measurement session lasted 90 minutes and consisted of an n-butanol test followed by four pig house air samples. Each sample was analyzed in 3 to 4 dilution series and by four panel members.

## 3. Results and discussion

### 3.1 Panel selection tests

Up to present, 43 persons are being tested for qualification as a panel member. As required by CEN, 30 of which already participated in 3 olfactometric measurement sessions on nonconsecutive days with n-butanol. The results of these 30 candidate panel members are further discussed.

#### 3.1.1. First criterion: geometric mean of the individual threshold estimates

Figure 1 represents the logarithms (log) of the geometric mean ($\bar{y}$) of the individual threshold estimates (ITE), expressed in mass concentration units of the reference gas, for the panel candidates. The limiting values for this criterion are 20 and 80 ppb, or respectively 1.3 and 1.9 in $\log\bar{y}_{ITE,}$ as indicated by the horizontal lines in Figure 1. A normality test was performed in SPSS and the logarithmic values have a normal distribution. The most sensitive of the tested persons detected n-butanol at a concentration of 18 ppb ($\log\bar{y}_{ITE}$ = 1.26), the least sensitive person had a mean odour detection threshold at a concentration of 860 ppb ($\log \bar{y}_{ITE}$ = 2.93) of n-butanol. From the 30 tested persons, 20 persons passed the first criterion. So overall, 67 % of the tested persons had an olfactory sensitivity within the specified range to qualify as a panel member according to CEN EN 13725.

#### 3.1.2. Second criterion: antilog value of the standard deviation on the individual threshold estimates

Figure 2 shows the antilog values of the standard deviation, calculated from the logarithms of the individual threshold estimates, expressed in mass concentration units of the reference gas, for the different panel candidates. The individual values for criterion 2 ranged from 1.5 to 5.8, as can be seen in Figure 2. The upper limit value for criterion 2 is 2.3 and is indicated by the horizontal line in Figure 2. From the 30 tested persons, 18 persons passed the second criterion. Overall, 60 % of the tested persons passes for the repeatability criterion.

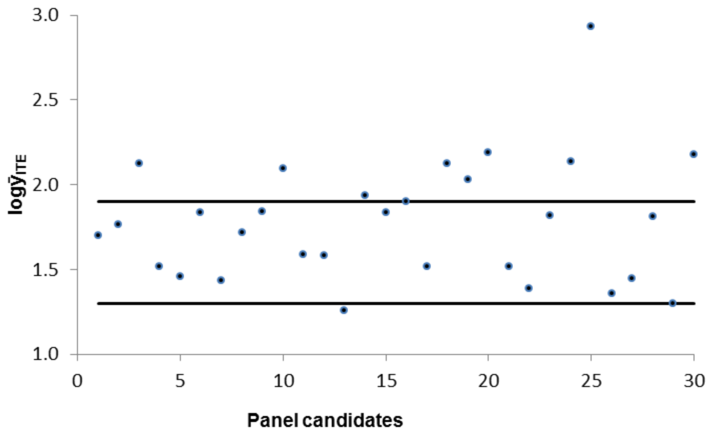


*Figure 1: Plot of the logarithm of the geometric mean of the individual threshold estimates ($\log\bar{y}_{ITE}$) of the 30 tested persons, with the upper and lower limit values according to CEN EN 13725.*

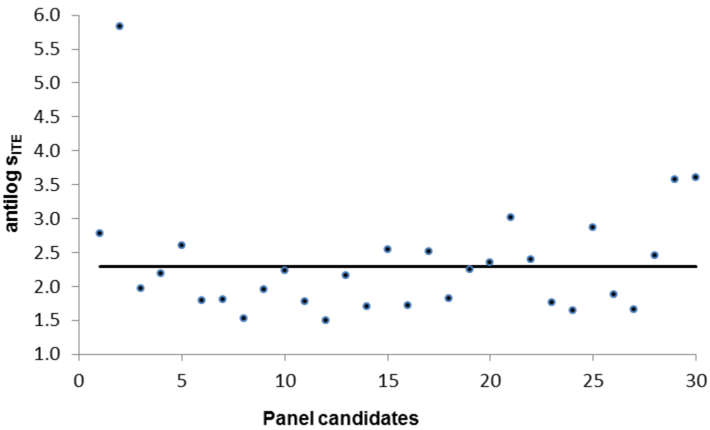


*Figure 2: Plot of the antilog of the standard deviation calculated from the logarithms of the individual threshold estimates from the different persons, with the upper limit value according to CEN EN 13725.*

### 3.1.3. Overall discussion

In total, 11 persons (36.7 %) passed for both criteria of the CEN standard, and only 3 persons failed for both criteria. There are 4 different populations within the 30 tested panel candidates: 11 persons who passed for both criteria, 7 persons who failed only for the sensitivity criterion, 9 persons who failed only for the repeatability criterion and 3 persons who failed for both tests.
As Defoer and Van Langenhove (2004) mentioned, the criteria of the European Standard are rather stringent. This makes it quite a task to select and sustain a sufficiently large odour panel for performing odour measurements on a regular basis.

In our experience, CEN EN 13725 clearly addresses the panel selection criteria and the panel selection calculations. CEN is however less detailed about how to constitute measurement sessions for the odour panel selection. Some examples are: (1) the number of individual threshold estimates that should be determined in the different panel selection sessions, in order to achieve the most reliable data from the candidates (2) the duration of a panel selection session, (3) the use of pauses longer than 30 s between dilution series, in order to avoid influence of possible adaptation of the nose.

### 3.2 Sampling campaign in Diksmuide

Odour samples were taken at a pig fattening farm in Diksmuide, in both a traditional and a low ammonia emission compartment. Olfactometric analysis of the samples was performed in the laboratorium at ILVO within 30 h after sampling. Table 2 represents the measured odour concentrations per compartment and per sampling date (period of January-March 2012). For each compartment the odour concentrations of the duplicates (indicated by D1 and D2) are given.

The measured odour concentrations range from 861 $ou_E/m^3$ to 17,027 $ou_E/m^3$ for the traditional compartment (T.C.), and from 483 $ou_E/m^3$ to 11,585 $ou_E/m^3$ for the low ammonia emission compartment (L.A.E.C.) (Table 2). As can be seen in Table 1, Van Langenhove and Defoer (2002) measured odour concentrations in the range from 737 $ou_E/m^3$ to 13,109 $ou_E/m^3$ for fattening pigs during Winter. It can be concluded that the new data are in the same range of those determined in 2002 by Van Langenhove and Defoer.

*Table 2: Odour concentrations ($ou_E/m^3$) in the two compartments of the pig fattening farm in Diksmuide.*

| Sampling date | | 12/01/12 | 26/01/12 | 09/02/12 | 13/02/12 | 01/03/12 |
|---|---|---|---|---|---|---|
| Compartment | Sample | Concentration ($ou_E/m^3$) | Concentration ($ou_E/m^3$) | Concentration ($ou_E/m^3$) | Concentration ($ou_E/m^3$) | Concentration ($ou_E/m^3$) |
| T.C. | D1 | 1,825 | 861 | 4,664 | 5,793 | 17,027 |
| | D2 | 2,896 | 967 | 4,277 | 5,793 | 11,585 |
| | Mean | 2,361 | 914 | 4,471 | 5,793 | 14,306 |
| L.A.E.C | D1 | 5,793 | 756 | 8,192 | 6,049 | 2,896 |
| | D2 | 3,379 | 483 | 2,896 | 6,889 | 11,585 |
| | Mean | 4,586 | 620 | 5,544 | 6,469 | 7,241 |

*Table 3: Relative differences (%) between the duplicates.*

| Sampling date<br>Relative difference between duplicates | 12/01/12<br>R.D.(%) | 26/01/12<br>R.D.(%) | 09/02/12<br>R.D.(%) | 13/02/12<br>R.D.(%) | 01/03/12<br>R.D.(%) |
|---|---|---|---|---|---|
| Traditional compartment | 45 | 12 | 9 | 0 | 38 |
| Low ammonia emission compartment | 53 | 44 | 96 | 13 | 120 |

The relative difference (R.D.) between the duplicates (calculated as the absolute difference between the duplicates divided by their mean value) ranged from 0 % up to 120 % (Table 3). Similar relative differences were found between duplicates in Van Langenhove and Defoer (2002). These variations between duplicates also seem to be in line with CEN EN 13725 (Annex G). This aspect, however, will be further investigated when all data are of the sampling campaign are available.

Table 2 also presents the mean odour concentrations for each compartment and per sampling day. In both compartments, an evolution in time of the odour concentrations can be seen. The odour results of the 26$^{th}$ of January are much lower than those of the 12$^{th}$ of January. This could indicate an effect of wet cleaning in both compartments, which was performed between the 16$^{th}$ and 23$^{th}$ of January. From February the 9$^{th}$ onward, the odour concentrations raised. On the 1$^{st}$ of March the odour concentrations were the highest. This evolution in time of the odour concentrations could be related to animal age, phase feeding and environmental conditions, and will be further investigated after the sampling campaign is ended (June 2012). So far, these preliminary results show no significant difference between the low ammonia emission and traditional compartments. This will be further investigated during the final data analysis at the end of the sampling campaign.

In order to better evaluate the obtained odour results, further experiments will be carried out to validate the sampling protocol (e.g. influence of sampling duration and time between sampling and analysis, avoiding the risk of condensation in the sampling bags). Also the measurement protocol will be further optimized (e.g. number of panel members per measurement, number of dilution series per sample, duration of the measurement session in relation to possible adaptation of the nose during measurements).

## 4. Conclusions

Both the agricultural sector and the Flemish government are in urgent need of scientific support concerning reliable and up to date odour emission values from intensive animal production systems. In cooperation with Ghent University, ILVO has set up a new research line and started with the development of an odour lab according to CEN EN 13725. In November 2011, the panel selection procedure was started. Up to present 11 qualified panel members were selected out of 30 fully tested candidates. Only 3 of these tested persons failed for both panel selection criteria according to CEN; 16 panel candidates failed for the sensitivity or the repeatability criterion. These first experiences with CEN and panel selection measurements, resulted also in some questions on how to get the 'best results' from a panel member, avoiding e.g. possible adaptation influences. The panel selection procedure will be continued during 2012, together with the follow-up of the present panel members.

A first odour sampling campaign was started in January 2012 at a pig fattening facility in Diksmuide (Belgium). Both a traditional and low ammonia emission compartment were sampled in duplicate. Olfactometric analysis was done in the odour lab at ILVO with the qualified panel members and candidates with good performances during their first n butanol test sessions. The first results of this measurement campaign are still preliminary, but could possibly indicate an effect of the performed wet cleaning procedure. So far, the obtained results indicated no significant difference between the conventional and the low ammonia emission housing system. The measurement campaign will be continued and the effect of possible influencing parameters will be further analyzed. Further experiments will also be conducted to optimize both the sampling and measurement protocols.

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