CHEMICAL ENGINEERING TRANSACTIONS
VOL. 40, 2014
A publication of AIDIC
The Italian Association of Chemical Engineering
www.aidic.it/cet
Guest Editor: Renato Del Rosso

ISBN 978-88-95608-31-0; **ISSN** 2283-9216
DOI: 10.3303/CET1440002

Online or Delayed Olfactometry – a Comparison Based on Results from Four Different Types of Pig Housing or Mitigation Systems

Kristoffer E. N. Jonassen*[a], Mai Britt F. Nielsen[a], Michael J. Hansen[b]

[a]Pig Research Centre, Danish Agriculture & Food Council, Axeltorv 3, DK-1609 Copenhagen, Denmark
[b]Department of Engineering, Aarhus University, Hangøvej 2, DK-8200 Aarhus N, Denmark
krj@lf.dk

The performance of on-site measurements by dynamic olfactometry using a mobile laboratory with online measurements was compared with delayed olfactometric analysis carried out by two external laboratories using the same kind of olfactometer as the mobile laboratory. All sampling and analyses were performed according to CEN 13725:2003, and analyses at the external laboratories were carried out within 24 hours of sampling. Sampling was not performed at the mobile laboratory, since the olfactometer was connected directly to the source with a heated sampling tube. In total, results for 120 odour measurements, representing four different types of pig housing or mitigation systems, were compared.
Due to the direct connection between the olfactometer and the source in the mobile laboratory, there was no time delay or other effects (e.g. sampling bags, temperature or condensation) that could affect the results. The number of panellists used in the mobile laboratory was lower than that used in one of the two external laboratories. The results for each sample were compared in order to evaluate the overall performance of the three laboratories with regard to concentration levels and variance.
The study shows a statistically significant difference between the results from the three laboratories. The variance in the mobile laboratory with online measurements was lower than that in the two laboratories using delayed olfactometry, and most of the difference was due to day-to-day variance.

1. Introduction

Odour nuisance from intensive pig production is a well-known problem for people living in the vicinity of pig production facilities, and increased attention during recent years has resulted in the development of housing and mitigation systems aimed at reducing odour emissions from pig production facilities. The evaluation of these systems is based on the collection of air samples which are typically analysed by dynamic olfactometry the following day, as described in the European standard for dynamic olfactometry (CEN, 2003). However, it has been demonstrated that the recovery of chemical odorants decreases over time when the air is stored in sample bags (Hansen et al., 2011; Trabue et al., 2006), and this could influence the evaluation of both housing and mitigation systems.
The aim of this study was to use a mobile olfactometric laboratory and compare results from on-site online measurements using dynamic olfactometry with results from delayed dynamic olfactometry, where the samples are stored in bags for approx. 24 hours.

2. Method and materials

2.1 Online olfactometry

A mobile laboratory was constructed in a trailer with a separate room for olfactometric analysis. The room contained an olfactometer (TO8, Odournet GmbH, Kiel, Germany). The room was equipped with air conditioning with a charcoal filter in the air inlet. The dilution air was supplied to the olfactometer via a compressor (Dr. sonic, Fini, Bologna, Italy), and, before entering the olfactometer, the dilution air was filtered through a column containing silica gel and charcoal. The compressor was placed within 25 m of the

Please cite this article as: Jonassen K., Nielsen M.B., Hansen M., 2014, Online or delayed olfactometry – a comparison based on results from four different types of pig housing or mitigation systems, Chemical Engineering Transactions, 40, 7-12 DOI: 10.3303/CET1440002

mobile laboratory. The mobile laboratory was connected to two odour sources at a time by a 30 m insulated and heated Teflon tube (inner diameter: 6 mm, and outer diameter: 8 mm, Mikrolab A/S, Aarhus, Denmark). The Teflon tubes were continuously flushed with a diaphragm Teflon pump (Capex L2, Charles Austen Pumps Ltd, Byfleet, UK) with a flow of approx. 7 L min^{-1}. A 0.2 µm Teflon filter (POLYVENT^{TM} 16, GE Healthcare Europe GmbH, Brøndby, Denmark) was used at the end of the sample line to protect the analytical instruments from dust particles.
A total of nine panellists, selected according to the European standard for dynamic olfactometry (CEN, 2003), were used during this study. Four panellists were used each day. On each measurement day, six measurements were performed, and each measurement was a result of three sequences.

2.2 Delayed olfactometry

All odour samples taken for delayed olfactometric analysis were collected in 30 L Nalophan (PET) bags using the lung principle. The bags were connected to the sampling point with a Teflon (PTFE) tube (inner diameter: 8 mm, and outer diameter: 9 mm). Identical samples for analysis at two laboratories were filled simultaneously using parallel tubes of the same length to connect the sample point to the bags. On each measurement day, six samples were collected for each laboratory. The sampling time was 15 minutes, and the air flow 1.9 L min^{-1}. 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, approx. 24 hours after sampling. This timespan was chosen for practical reasons and in order to lie within the standard. Temperature and relative humidity were measured at the sampling point during the sampling. On the following day, the samples were analysed at two external laboratories (Danish Technological Institute, Roskilde, Denmark and LUFA Nord-West, Oldenburg, Germany), both of which used TO8 olfactometers (Odournet GmbH, Kiel, Germany). In Lab 1, the total number of panellists used during this study was 13, and in Lab 2 the number is unknown. Both sampling and analyses were carried out in accordance with the standard (CEN, 2003).

Figure 1: Left: The mobile laboratory parked next to a pig production facility, the laboratory was directly connected to the sources by isolated and heated Teflon tubes. Right: Sampling of odour bag for delayed olfactometry, the bags were connected to the sampling point with a Teflon tube.

2.3 Experimental set-up

The mobile laboratory was applied at four pig production facilities in Denmark, with different kinds of housing systems or mitigation systems. The systems were chosen in order to achieve as large a variety of odour sources as possible within pig production. The systems included slurry acidification (Jørgen Hyldgård Staldservice A/S, Holstebro, Denmark, installed at a facility with 500 growing-finishing pigs and an identical control facility), point extraction (where ventilation air was extracted both below the floor and though the roof, installed at a facility with 250 growing-finishing pigs), a standard housing system (where ventilation air was extracted though the roof in a facility with 380 growing-finishing pigs), and biological air-cleaning (Farm AirClean three-step Bioflex, SKOV A/S, Glyngøre, Denmark, installed at a facility with 350 growing-finishing pigs). At each facility, between three and six measurement days with three repetitions were carried out for each odour source (control versus slurry acidification, pit ventilation versus roof ventilation, normal roof ventilation, and before and after the biological air cleaner). Simultaneously with the measurements in the mobile laboratory, air samples were collected in 30 L Nalophan sample bags (see Figure 1 and 2). In total, the facilities were visited on 20 days during a six-month period (May – November

2013), and a total of 120 measurements were taken for each laboratory (only 114 measurements for Lab 2).

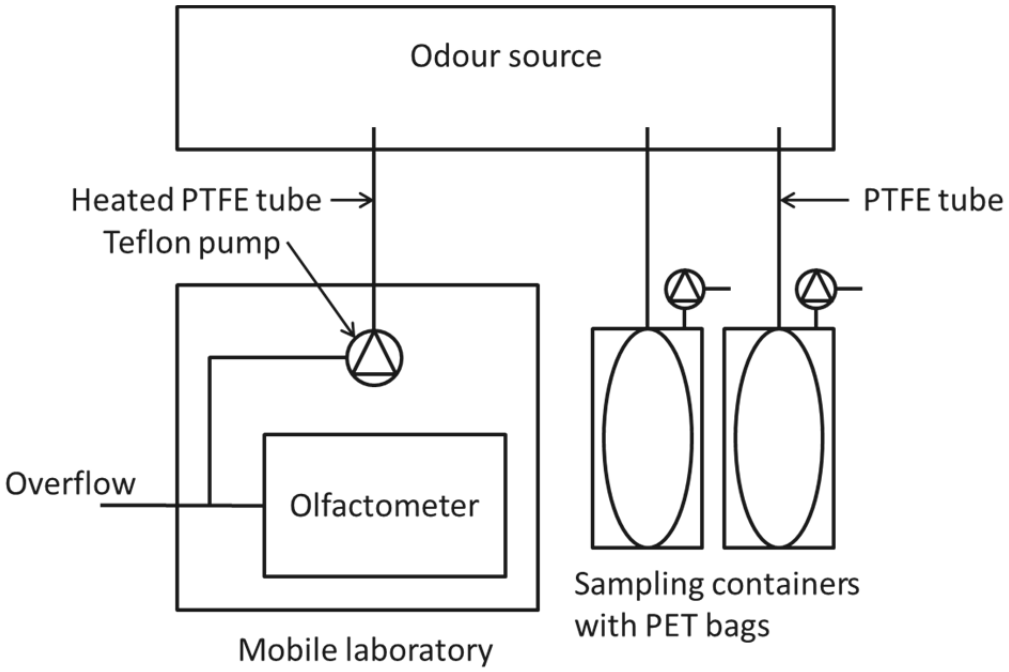

Figure 2: Schematic drawing of a mobile laboratory containing an olfactometer and sampling of bags for delayed olfactemetry

2.4 Statistics

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

3. Result and discussion

An overview of all the measurements is shown in Figure 3. The general trend is that the highest concentrations were measured in Lab 1 and the lowest in Lab 2. However, the on-site measurement from the mobile laboratory shows the highest concentration for the point extraction and the lowest for the standard housing system. Based on earlier work (Jonassen et al., 2012), the patterns between Lab 1 and Lab 2 were expected. Table 1 presents the overall mean concentration values for the results from three olfactometric laboratories. As seen, there was a statistically significant difference between the results from the three laboratories.

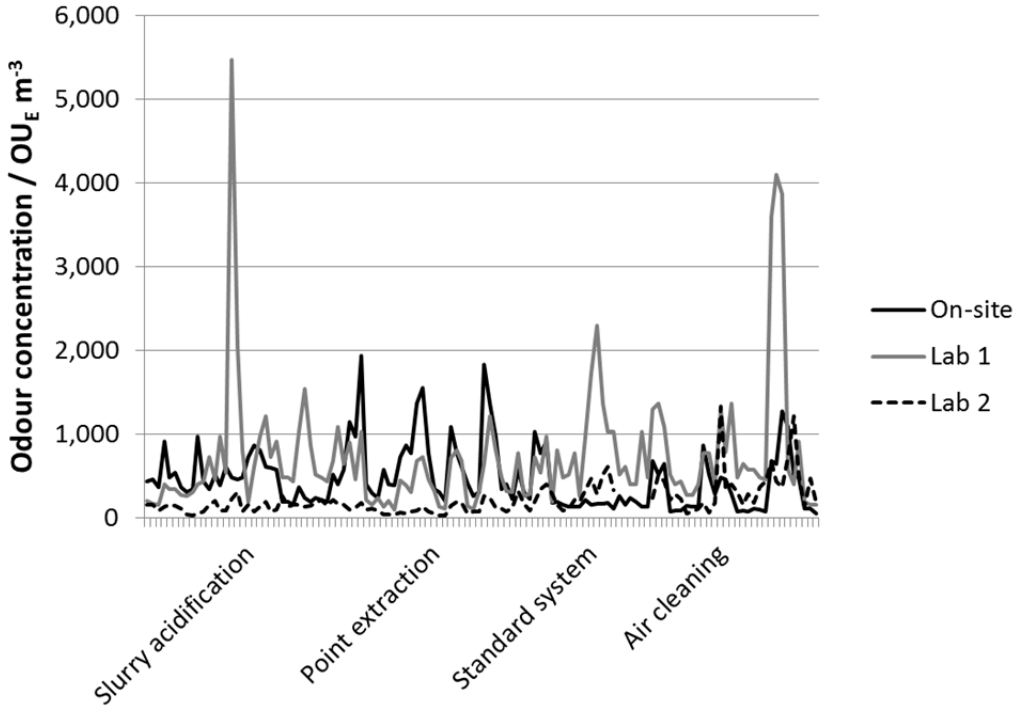

Figure 3: Results from three olfactometric laboratories for 120 odour samples from four pig facilities with different housing or mitigation systems. Black lines represent online measurements carried out using a mobile laboratory. Grey and dashed lines represent results from two external laboratories.

Table 1: Mean odour concentrations for measurements from four different pig facilities performed at three olfactometric laboratories. Numbers in brackets are 95% confidence interval, n=120 (for Lab 2, n=114).[a, b, c]: different letters in the same row indicate a statistically significant difference, P<0.0001.

Mean odour concentration	On-site	Lab 1	Lab 2
$\ln(OU_E\ m^{-3})$	5.8[a] (5.7-5.9)	6.3[b] (6.1-6.5)	5.1[c] (4.9-5.3)
$OU_E\ m^{-3}$	340[a] (300-380)	540[b] (430-670)	160[c] (130-210)

The variance of the mean odour concentrations (as natural logarithm values) in Table 1 are presented in Table 2. The variance in the two external laboratories is more than twice (0.37 and 0.40 respectively) the variance in the on-site laboratory. Several factors, such as time delay until analysis, physical or chemical changes of the odorants in the bag, adsorption, diffusion, temperature or condensation, could affect the results and could explain the differences between the online and delayed analyses. However, most of the differences do not lie within the days, which could be explained by the general factors mentioned above, but between the days (Table 2). The day-to-day variances in the laboratories are 0.04 for the on-site measurements and 0.22 and 0.24 respectively in the two external laboratories. Two factors could explain this observation: the number of panellists in each laboratory used throughout the study, and the fact that the composition of odorants in the samples from the different sources is different. The concentration of key odorants, e.g. H_2S, in the sampling bags decreases over time (Guillot and Beghi, 2008), and the losses are non-uniform for different odorants (Hansen et al., 2011). The effect of this factor on the measurable effects of mitigation technologies is discussed elsewhere (Hansen et al., 2014).

Table 2: The variance in the logarithm of the mean odour concentrations shown in Table 1, n=120 (for Lab 2, n=114).

	On-site	Lab 1	Lab 2
Variance	0.14	0.37	0.40
-within days	0.10	0.15	0.16
-between days	0.04	0.22	0.24

Since most of the variance in the two external laboratories does not lie within the days or the individual panels, but between the days or the panels, and since the variance between days is lowest in the on-site laboratory without sampling, the number of panellists used in the study and the frequency with which each panellist is used are compared in the on-site laboratory and Lab 1. Figure 4 shows the number of sessions each panellist participated in. Although the number of panellists in the two laboratories was nine and 13, respectively, three of the panellists in Lab 1 only participated in one session, and therefore, in practice, the overall number of panellists is comparable and cannot explain the differences in the day-to-day variance. On the other hand, the frequency with which each panellist is used has a different pattern in the two laboratories. In Lab 1, ten of the panellists participated in between three and 12 sessions, whereas four panellists in the on-site laboratory participated in between 12 and 15 sessions, and the last five between three and seven sessions. This non-uniform use of panellists in the two laboratories can explain some of the differences in the day-to-day variance.

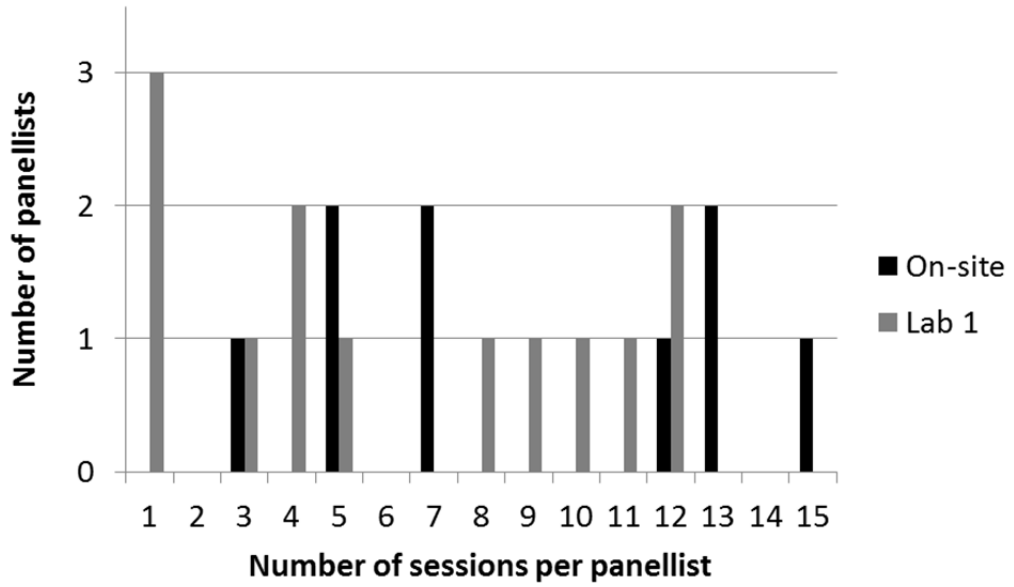

Figure 4: The number of panellists and the number of sessions each panellist participated in in the on-site laboratory and Lab 1.

4. Conclusions

It has been shown that the measurements from three olfactometric laboratories for samples from four pig facilities with different housing or mitigation systems are statistically significantly different. The variance in the mobile laboratory with online measurements was lower than that in the two external laboratories using delayed olfactometry. Most of the difference was due to day-to-day variance and could not be explained by a lower overall number of panellists in the mobile laboratory. However, it could partly be explained by the frequency with which each panellist is used in the two laboratories.

References

CEN EN 13725:2003, Air quality - Determination of odour concentration by dynamic olfactometry

Guillot, J.-M., Beghi, S., 2008, Permeability to water vapour and hydrogen sulphide of some sampling bags recommended by EN 13725, Chemical Engineering Transactions, 15, 79-85

Hansen, M.J., Adamsen, A.P.S., Feilberg, A., Jonassen, K.E.N., 2011, Stability of odorants from pig production in sampling bags for olfactometry, J. Environ. Qual., 40, 1096-1102

Hansen, M.J., Jonassen, K.E.N., Feilberg, A., 2014, Evaluation of abatement technologies for pig houses by dynamic olfactometry and on-line mass spectrometry, Chemical Engineering Transactions, 40, xx-xx

Jonassen, K.E.N., Pedersen, P., Riis, A.L., Sørensen, K., 2012, Does the Choice of Olfactometric Laboratory Affect the Efficiency of Odour Abatement Technologies?, Chemical Engineering Transactions, 30, 43-48

Trabue, S.L., Anhalt, J.C., Zahn, J.A., 2006. Bias of Tedlar bags in the measurement of agricultural odorants. J Environ Qual 35, 1668-1677.