# PIG-HOUSE ODOURS – A REVIEW USING ODOUR ACTIVITY VALUES


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**Abstract – This paper reviews the literature on pig-house odours using odour activity values to determine the main compound classes contributing to pig-house odour. These are short chain acids, sulphur compounds, phenols, indoles and amines. These compounds have the highest odour activity values and pungent and offensive odours.**

**The contribution to the offensive odour by these compounds is affected by location, timing and method of analysis. Mitigation factors related to slurry management or pig diets have differential effects on these classes of odorous compounds.**



**Key Words –animal house, pig odour, slurry odour.**


## I. INTRODUCTION

The odour downwind from pig-houses can be offensive to nearby residents. Researchers have reported up to five hundred different volatile organic compounds emitted from pig production facilities (*1*). However, it is often unclear which of these many compounds make the most important contribution to the noxious odour. Furthermore, the composition of the odour from the waste itself may differ depending on the location sampled and the methods used (*2*).

Quantification of volatile compounds from pig-houses has been used to estimate the effectiveness of any mitigation factors employed to reduce them. However, few have attempted to determine which of these many compounds makes the greatest contribution to the offensive odour.

Calculation of an odour activity value (OAV) is a method widely used in flavour chemistry to identify those odours with the potential to contribute most to an odorant mixture and is defined as the concentration of a single compound divided by the odour threshold concentration for that compound (*3*). Compounds with an OAV greater than 1.0 are likely to contribute to the overall odour of a sample mix and compounds with large OAV would contribute substantially.

The odour thresholds reported in the literature can vary considerably, with sometimes a range of several orders of magnitude for a particular chemical compound. In order to minimise the impact of this variability on the odour activity values derived, a consistent set of odour thresholds is required for the compounds determined in pig-house odour.

Two research groups have used odour activity values (OAVs) for studies on pig-house and have assessed the impact of a limited list of compounds (<20) for their own analyses only (*4, 5*).

The aim of this work was to evaluate the relative importance for pig-house odour of a comprehensive list of volatile compounds reported by a number of authors from pig house emissions. This was achieved through a reanalysis of the extensive published data using a consistent set of odour thresholds to calculate OAVs.

## II. MATERIALS AND METHODS

The odour detection threshold (ODT) is usually determined as the concentration at which 50% of assessors can detect an odour.

No one research group has determined odour detection thresholds for all the odour compounds of interest. Nagata et al. (*6*) measured the odour thresholds of 223 chemicals by the Japanese triangular bag method. For some compounds, Nagata et al (*6*) did not report an ODT; then one was estimated from another source. The methods used and the resulting set of odour threshold data, denoted "Nagata+", is presented elsewhere (*7*).

A second set of odour thresholds ("Devos+") was based on the list published by Devos et al. (*8*), taken from over a hundred references for over six hundred chemical compounds. OAVs were also calculated using the "Devos+" list and are presented elsewhere (*7*).

Out of 89 papers on pig-house odours, 22 were identified which presented quantitative data of the air or slurry headspace concentration of volatile compounds released from piggery facilities. Some of these had collected volatile odour compounds using Tedlar odour bags and others using thermal desorption from adsorption tubes. Furthermore, the location and type of sample varied.

The concentrations of volatile compounds released from pig-houses have been collated from the literature and the OAV values presented in this paper were calculated by using the ODTs from the "Nagata+ list".

$$\text{OAV} = \frac{[\text{compound in air (mg m}^{-3})]}{\text{ODT in air (mg m}^{-3})}$$

## III. RESULTS AND DISCUSSION

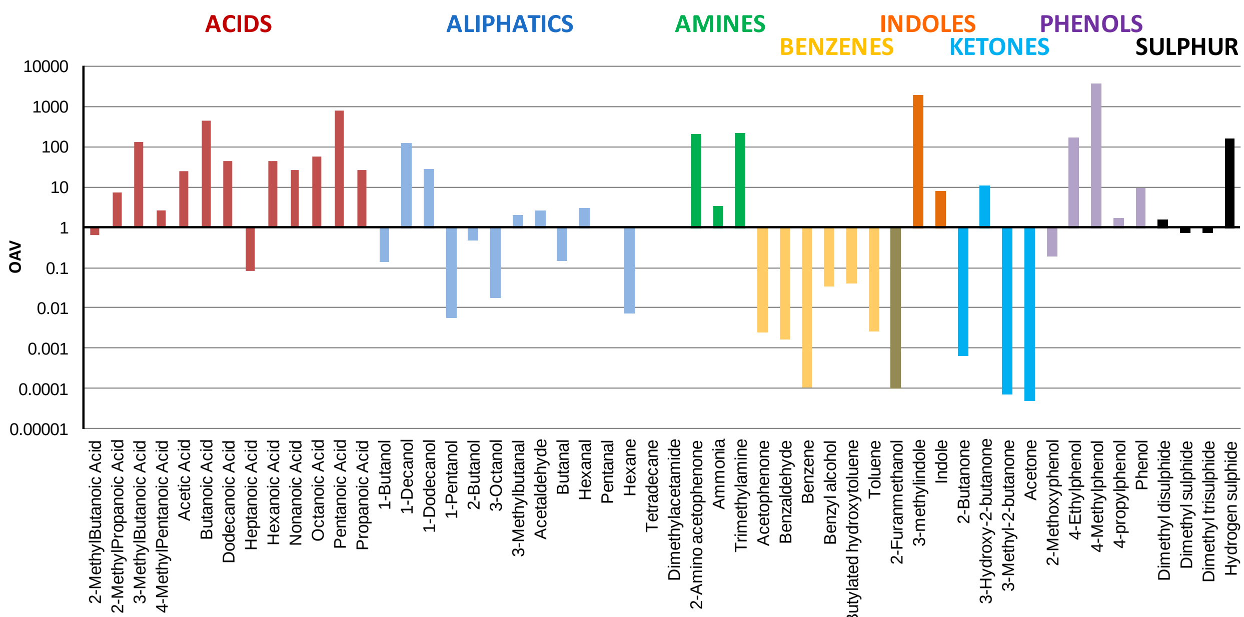
Figure 1 presents the mean OAV, calculated using the "Nagata+ list", from those publications which reported quantitative data using adsorption tubes for these compounds. A simple mean of variable data can only provide a very approximate picture of the relative OAVs of the compounds shown and the data is examined in more detail elsewhere (*7*). However, an examination of the results from the individual authors showed good agreement on the identity of the compounds with the highest OAVs. The OAVs calculated using the "Devos+ list" (not shown) showed similar relative trends. Figure 1 therefore provides a reasonable illustration of the relative importance of the compounds shown.

Short chain acids were important for pig-house odour whether collected from slurry or adjacent to the pig-house itself. They were more prevalent when collected using thermal desorption rather than odour bags (*7*). These acids result from intestinal microbial activity in the large intestine and cause rancid, cheese, faecal odours. OAVs only show the relative importance of individual odour compounds and different compounds, especially from the same compound class, can have a cumulative effect. The large number of acids detected at above their ODT suggests that these may have a greater combined effect.

Ammonia is frequently associated with pig-house odour within the industry. However, these results confirm previous work (*2*), showing that amines are only one of many odorous compound classes.

Indoles, including the compounds 3-methylindole or skatole, and alkylphenols are well known for their faeces-like and pungent odours. They were consistently present at high odour activity values. Indoles are formed in the gut by microbial metabolism of tryptophan and the alkyphenols are formed by microbial fermentation of tyrosine and phenylalanine.

Figure 1. Compounds contributing to pig-house odour, determined by thermal desorption



Some aliphatic and aromatic compounds (‘aliphatics’, ‘ketones’, ‘benzenes’) are reported occasionally at sufficient concentrations to give an OAV>1, and may sometimes contribute to pig-house odour. However, their odour is not generally unpleasant and their OAV is generally considerably lower than that of other compound classes and it is unlikely that they will make a large contribution to pig-house odour.

These data (illustrated in Figure 1) show that the most important compound classes for pig-house odour are short chain acids, sulphur compounds, phenols, indoles and amines.

Where suitable quantitative data was published, it has been possible to use the same approach to re-evaluate data on potential mitigation factors. Figures 2 and 3 shows the results for two of these: covering the slurry tank (*9*) and increasing the liquid content of the diet (*10*).

Figure 2 shows that the most important odour compounds change during 9 weeks storage and that covering the slurry reduces the impact of ammonia, indoles and phenols but has little effect on the impact of acids or sulphur compounds (*9*).

In contrast, increasing the liquid component of the diet (Figure 3) decreases the contribution to the odour of acids and sulphur compounds, but has little effect on other compounds (*10*). Thus, different mitigation factors influence different compound classes. This suggests that there is no single method for reducing pig-house odour. This has implications for the selection of abatement strategies.

Figure 2. Effect of covering and ageing slurry on odour activity of compound classes (*9*)

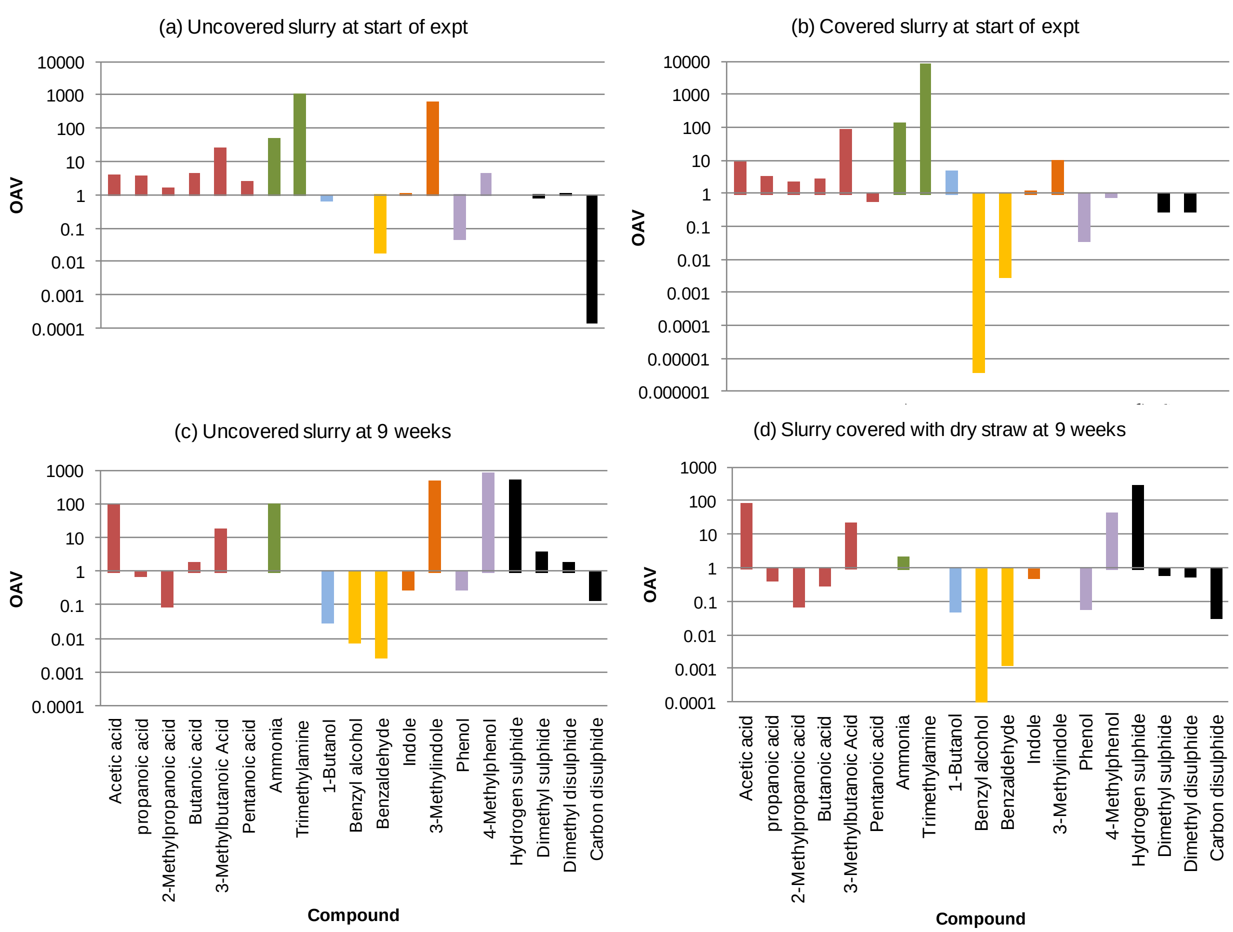
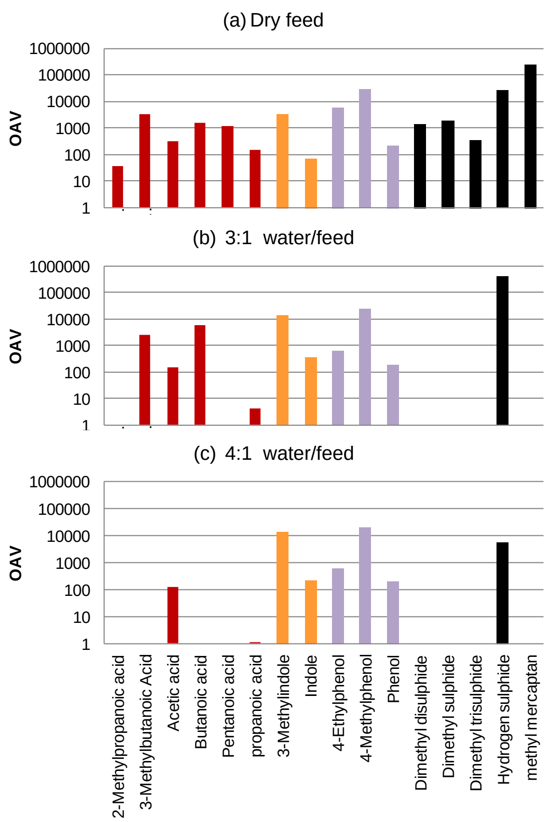


Figure 3. Effect of liquid diet on odour activity of pig-house odours (*10*)




## IV. CONCLUSION

The most important odour compounds contributing to pig-house odour are short chain acids, sulphur compounds, phenols, indoles and amines. These compounds have the highest odour activity values and often have pungent and offensive odours.

The odour activity of these compounds is affected by a number of factors, including method of analysis. Potential mitigation factors related to slurry management or pig diets have differential effects on these classes of odorous compounds, suggesting that there is no single solution to the problem of pig-house odour and that an analysis of the compounds responsible is essential before considering mitigation strategies.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## REFERENCES


(1) Ni, J.Q., Robarge, W. P., Xiao, C. H. & Heber, A. J. (2012) Volatile organic compounds at swine facilities: A critical review. *Chemosphere*. **89**, 769-788.

(2) O'Neill, D.H., & Phillips, V.R.A. (1992) Review of the control of odour nuisance from livestock buildings: Part 3: Properties of the odorous substances which have been identified in livestock wastes or in the air around them. *Journal of Agricultural Engineering Research*. **53**, 23-50.

(3) Acree, T., Barnard, J., & Cunningham, D. (1984) A procedure for the sensory analysis of gas chromatographic effluents. *Food Chemistry*. **14.**, 273-286.

(4) Trabue, S.K., B.; Bearson, B. & Ziemer, C. (2011) Swine Odor Analyzed by Odor Panels and Chemical Techniques. *Journal of Environmental Quality*. **40**, 1510-1520.

(5) Parker, D.B., Koziel, J. A., Cai, L., Jacobson, L. D., Akdeniz, N., Bereznicki, S. D., Lim, T. T., Caraway, E. A., Zhang, S., Hoff, S. J., Heber, A. J., Heathcote, K. Y. & Hetchler, B. P. (2012) Odor and Odorous Chemical Emissions from Animal Buildings: Part 6. Odor Activity Value. *Transactions of the Asabe*. **55**, 2357-2368.

(6) Nagata, Y. (2003) Measurement of odor threshold by triangle odor bag method, In: Odor measurement review, pp118-127, Office of Odor, Noise and Vibration, Environmental Management Bureau, Ministry of the Environmented^eds: Government of Japan.

(7) Kennedy, J.T., Farmer, L.J. & Magowan, E. . (2015) The measurement of Odour Activity Values in Pig-House Air: Part 1. Identication of the Main Odour Compounds. *(in preparation)*.

(8) Devos, M., Patte, F., Rouault, J, Laffort, P. & Gemert, L.J. (1990) *Standardised Human Olfactory Thresholds.*, New York.: Oxford University Press.

(9) Blanes-Vidal, V., Hansen, M.N., & Sousa, P. (2009c) Reduction of Odor and Odorant Emissions from Slurry Stores by Means of Straw Covers. *Journal of Environmental Quality*. **38**, 1518-1527.

(10) Hobbs, P.J., Misselbrook, T. H. & Pain, B. F. (1997) Characterisation of odorous compounds and emissions from slurries produced from weaner pigs fed dry feed and liquid diets. *Journal of the Science of Food and Agriculture*. **73**, 437-445.