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PERSISTENCE: ODOUR INTENSITY AND CONCENTRATION RELATIONSHIP FOR LIVESTOCK ODOURS

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Abstract

Odour persistence is a measure of the relative change in odour intensity to the number of odour dilutions. Odour intensity of a non-diluted source is measured by comparing an n-butanol concentration to the odour source using a recognized Odour Intensity Referencing Scale (OIRS). In a previous study, the n-butanol intensity as described by the OIRS protocol was related to concentration (OU/m^3) by an olfactometer. The objective of this study was to measure odour persistence from 8 odour sources: broiler manure; layer manure; dairy manure; swine manure; exhaust air from a pig gestation, nursery, and finisher facilities and artificial livestock odour (ALO). Persistence values ranged between -0.87 for stored swine manure to -1.86 for a prepared Artificial Livestock Odour. The higher persistence values appear to be associated with sulphur-containing compounds in the source. Swine odours and dairy manure odour were the most persistent. Odour dispersion models need to include persistence values to determine MDS values. The persistence of n-butanol is similar to that of the exhaust air from a finisher barn.

INTRODUCTION

The most important parameters used in quantifying an odour are odour concentration and intensity. The odour concentration of an air sample is defined as the dilution factor required to reach the detection threshold (ASTM 1991; CEN, 2003). The odour intensity of a non-diluted air sample is the perceived strength by the human olfactory system. The relationship between the odour concentration and odour intensity has been a long-standing research topic investigated by a number of researchers. Weber (Leri, 1997) found that a ratio of total sensation to a threshold of sensation exists for all human senses, including the olfactory sense. Fechner (Nicolai et al. 2000) formulated this principal as the intensity of a sensation increasing as the log of stimulus increases, i.e., equal changes of odour threshold ratios lead to equal differences between perceived intensities, according to the Weber-Fechner law. Steven (1957) proposed that the relationship between the detection threshold and the intensity is an exponential function.

To measure odour intensity, an odour intensity referencing scale (OIRS) is used which can consist of a scale of 5, 8, 10 or 12 points of intensity. The OIRS system is defined in ASTM E544 (1999) and reported by McGinley (2000). An important aspect in the training process of odour sniffers is to determine if the specified concentration of the OIRS is reliable and repeatable. During an odour sniffer's training event, the air surrounding the person's nose is entrained into the headspace of the OIRS container containing the n-butanol liquid. This leads to dilution of the specified odourant thus changing the expected original concentration. Also, dilution occurs as the lid of the container is opened before the odour sniffer has a chance to smell the solution. Also, the cited equations in the literature do not relate the intensity and concentration at n-butanol concentrations below 60 OU/m^3. In a recent study, the relationship between the perceived intensity of the headspace of standard 60-mL training jars containing n-butanol concentration (ppm) of the 8-point OIRS measured by odour sniffers and the corresponding n-butanol concentration (OU/m^3) determined by an olfactometer (Segura and Feddes, 2005). These relationships are presented in Table 1 and plotted in Figure 1. The results from this study were used to determine the persistence values for different types of livestock manure.

.Table 1. Relationship of the 8-point scale of n-butanol in air and its corresponding concentrations using olfactometry and the theoretical concentrations based on the definition of one European odour unit (40 ppb or 1 OU/m^3).

[a]Level	[b]8-point n-butanol intensities (ppm)	[c]Revised n-butanol intensities ppm in air	Theoretical concentration OU/m^3	[d]Measured concentrations OU/m^3
1	12	0.06	2	2
2	24	0.14	4	5
3	48	0.34	9	12
4	96	0.82	21	26
5	194	2.02	51	57
6	388	4.91	123	128
7	775	11.9	298	286
8	1550	29.0	724	637

[a] 8-point n-butanol intensity referencing scale (OIRS)
[b] n-butanol concentration in air based on ASTM Standard E:544-99
[c] Segura and Feddes, 2005
[d] Measured by presenting the revised intensities to the panelists

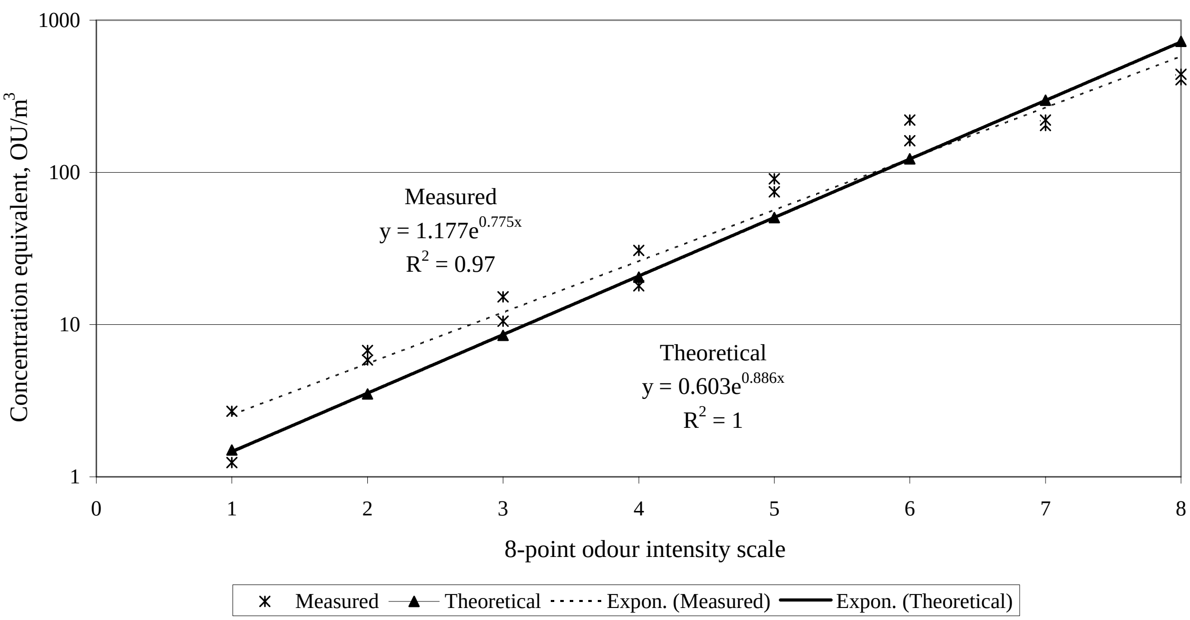

Figure 1: Relationship between the 8-POINT n-butanol OIRS scale and corresponding concentrations (Segura and Feddes, 2005)

PERSISTENCE

An odour's intensity is a measure of its perceived strength (ASTM, 1999: CEN, 2003). As an odour is diluted, intensity decreases. The rate with which an odour's intensity decreases with dilution is known as persistence and follows Stevens Law (CEN, 2003):

$I=kC^P$ or

$\log I = P\log C + \log k$

where:

I = intensity scale reference odour concentration in ppm;

P = persistence, rate of intensity change with dilution;

C = odour concentration or dilution ratio; and

k = odour's intensity undiluted or at full strength.

For example, Figure 2 illustrates a theoretical persistence curve for n-butanol, a reference gas used to train odour sniffers and olfactometer panelists. In Figure 2, 46.2 ppm n-butanol was the non-diluted sample. The persistence curve can be determined by calculating the logarithm of the n-butanol's concentration at different dilution ratios. Note that the theoretical 46.2 ppm n-butanol persistence curve intersects its geomean detection threshold (GDT) which is defined as 0.040 ppm n-butanol (CEN, 2003). For ease of data comparison, researchers measuring the persistence of livestock odours have used varying ranges of odour intensity reference scales (OIRS) based on different air concentrations of n-butanol. This allows any OIRS to be converted to a common intensity measurement, log [n-butanol, ppm], and the subsequent persistence measurements to be standardized. Also as a quality control check, the persistence determination of any odour should intersect their GDT at 0.040ppm or -1.4 base 10 logarithm.

Each odour has a different degree of persistence. As odours are diluted their intensity decreases at different rates and correspondingly require different amounts of dilutions to reach lower detection limit (LDT) intensity. If an odour's intensity criterion is known, the odour's persistence determines the dilutions required to reach that intensity.

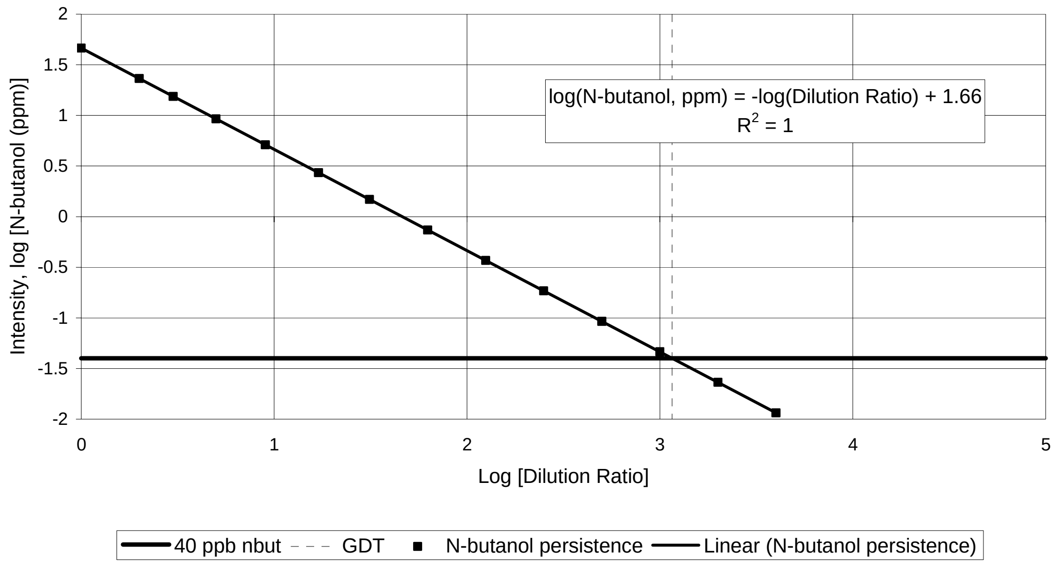

Figure 2: Theoretical n-butanol persistence curve (Segura and Feddes, 2005).

OBJECTIVE

The objective of this study was to measure odour persistence from 8 odour sources: broiler manure; layer manure; dairy manure; swine manure; exhaust air from a pig gestation, nursery, and finisher facilities and artificial livestock odour (ALO).

MATERIALS AND METHODS

The U of A olfactometer was used to determine the Geomean Dilution Threshold (GDT), and persistence curves of 8 odour sources: broiler manure, layer manure, dairy manure, swine manure, gestation exhaust air, nursery exhaust air, finisher exhaust air and artificial livestock odour (ALO) (Feddes et al. 2001). The odour source and materials were collected from the Edmonton Research Station. The olfactometer was operated to provide the following dilutions : 1:16000, 1:8000, 1:4000, 1:2000, 1:1000, 1:500, 1:250, 1:125 and 1:63. Dilution ratios below 1:63, especially with the stronger manure odours, were not considered since these dilutions contaminated the olfactometer. The dilutions were presented to each panelist for 5s for an initial attempt to record an intensity measurement. If required, a panelist was allowed repeat a sniffing session of 5s to assist in their intensity assessment. The revised OIRS values as presented in Table 1 were used to train and test the odour panelists on an 8-port olfactometer at the U of A odour lab. Using the 8-port olfactometer for odour dilution presentations and randomized dilution ratios is a reliable method to determine the persistence of the eight odour sources.

The persistence protocol was as follows:

For each source of odour the following was obtained:

a) Geomean Dilution Threshold (GDT) (Figure 2)

b) 8-point OIRS vs dilution ratio curve (2-3 times for each source)

c) 8 odour panelists were recruited for GDT and persistence measurements. Two 8-point OIRS training sessions were conducted using the 8-port olfactometer to present the OIRS to all 8 panelists simultaneously (scale 7 and 8 were not used). The olfactometer port flow rate was 20L/min for both the GDT and persistence measurements. During each training panel, a sequence of events and data sheets were used to record the panelist's responses. Similar to the protocol for GDT, the dilution ratio presentations for persistence were 15s in duration. A pause between dilution ratio presentations of 2 min ensured nasal fatigue was minimized. A typical training panel was conducted over a 2-h period.

RESULTS AND DISCUSSION

The persistence curves for the eight odour types: broiler manure, layer manure, dairy manure, swine manure, along with gestation exhaust air, nursery exhaust air, finisher exhaust air and ALO were obtained from panel sessions (Figure 3). Figure 3 summarizes the normalized persistence curves for the given sources. The odours were assumed to have an initial intensity of level 8. The persistence slope values of the odour sources are presented in Table 2. The values ranged from -0.87 for swine manure to -1.86 for the Artificial Livestock Odour (ALO). The ALO was designed to replace the reference gas n-butanol at some later date. The n-butanol gas has a different odour character from that of livestock odours. The higher the persistence value, the more persistent the odour is for a similar number of dilutions. The sources with the higher values are assumed to contain more sulphur containing compounds, whereas the sources with the lower values appear to contain more nitrogen containing compounds such as ammonia. It is interesting to note that the persistence of n-butanol is similar to that of the exhaust air from finisher facilities.

The persistence values also have implications for determining minimum separation distances (MDS). Sources with higher persistence values would have higher MDS values as illustrated in Figure 3. The horizontal line can be assumed to be the acceptable odour intensity at the receptor location. Odour dispersion models need to include these persistence values to reliably predict MDS values.

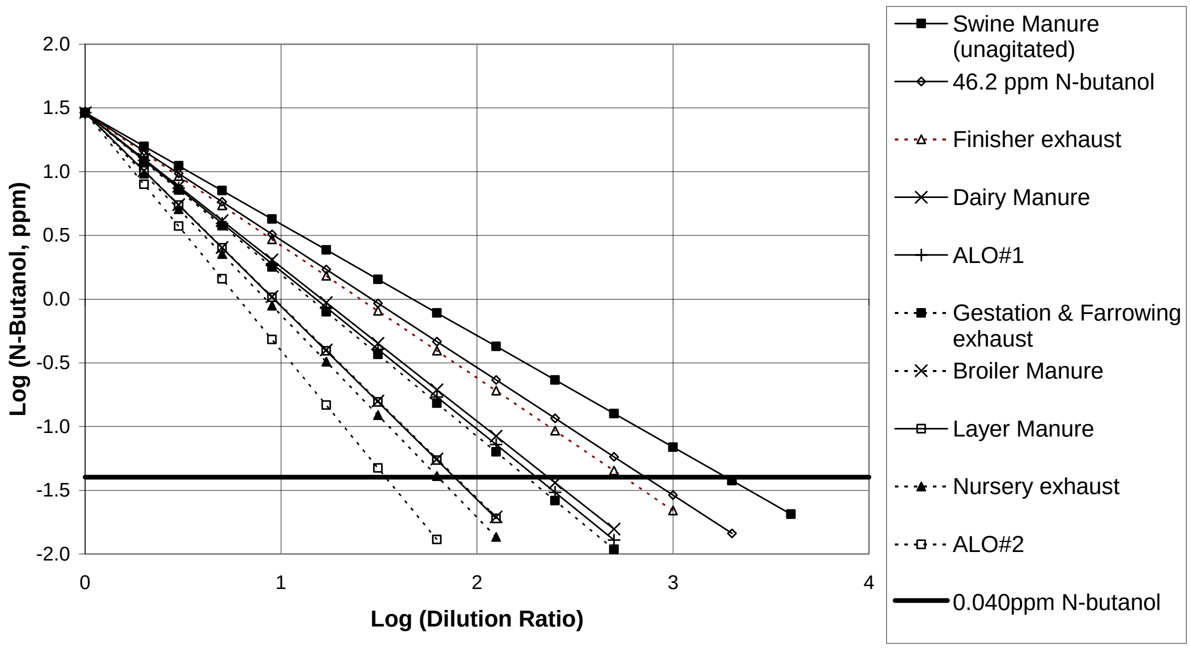

Figure 3: Persistence curves

Table 4: Persistence Slopes

Source	Persistence
Swine Manure (unagitated)	-0.87
N-butanol	-1.00
Finisher exhaust	-1.04
Dairy Manure	-1.21
ALO#1	-1.24
Gestation & Farrowing exhaust	-1.27
Broiler Manure	-1.51
Layer Manure	-1.52
Nursery exhaust	-1.59
ALO#2	-1.86

CONCLUSIONS

1) Persistence values ranged between -0.87 for stored swine manure to -1.86 for a prepared Artificial Livestock Odour
2) The higher persistence values are associated with sulphur-containing compounds in the source.
3) Swine odours and dairy manure odour were the most persistent.
4) Odour dispersion models need to include persistence values to determine MDS values.
5) The persistence of n-butanol is similar to that of the exhaust air from finisher facilities.

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