Persistence of livestock source odours

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Ouellette, C.A., J.C. Segura and J.J.R. Feddes. 2010. **Persistence of livestock source odours**. Canadian Biosystems Engineering/Le génie des biosystèmes au Canada. 52: 6.7–6.9. Odour persistence values were determined for seven odour sources: broiler manure; layer manure; dairy manure; swine manure; and exhaust air from pig gestation, nursery, and finisher facilities. These values were compared to that of a reference livestock odour, n-butanol. Persistence values ranged between −0.87 for stored swine manure and −1.59 for exhaust air from a pig nursery unit. Swine odours and dairy manure odour were the most persistent. The data suggest that odour dispersion models need to include odour persistence values to determine minimum distance separation (MDS) values for livestock operations. **Keywords:** animal odour origin, persistence, concentration, odour intensity.

Des valeurs de persistance des odeurs ont été mesurées pour sept sources différentes: le fumier de poulets de chair; Le fumier de poules pondeuses; le fumier de vache laitière, le lisier de porc et l'air provenant d'une maternité, d'une pouponnière et d'un engraissement porcin. Ces valeurs on été comparées à celle d'une odeur de référence utilisée dans le cas des élevages d'animaux, le n-butanol. Les valeurs de la persistance se situaient entre −0,87 pour le lisier de porc et −1,59 pour l'air provenant d'une maternité porcine. Les odeurs de lisier de porc et fumier de vache laitière ont été les plus persistantes. Les résultats obtenus suggèrent que les modèles de dispersion des odeurs doivent inclure des valeurs de la persistance des odeurs pour déterminer la distance minimale de séparation (DMS) pour les élevages d'animaux. **Mots clés:** odeur d'origine animale, persistance, concentration, intensité.

INTRODUCTION

The most important parameters used in quantifying an odour are concentration and intensity. The odour concentration of an air sample is defined as the dilution factor required to reach the detection threshold (ASTM 1991; BSI 2003). The odour intensity of an air sample is the strength as perceived by the human olfactory system (ASTM 1999; BSI 2003). As an odour is diluted, the intensity decreases. The relationship between the odour concentration and odour intensity has been a long-standing research topic investigated by a number of researchers. Leri (1997) cited research results that found that a ratio of total sensation to a threshold of sensation exists for all human senses, including the olfactory sense. This suggested that the intensity of a sensation increases as the log of the stimulus increases, i.e., equal changes of odour threshold ratios lead to equal differences between perceived intensities, according to the Weber-Fechner law (Nicolai et al. 2000; Zhang et al. 2002).

Stevens (1957) proposed that the relationship between the detection threshold and the perceived intensity is an exponential function. Steven's law is commonly accepted as the model for relating perceived odour intensity and odour dilutions (BSI 2003). The rate with which an odour's intensity decreases with dilution is known as persistence and follows Stevens Law:

$$I = kC^{P} \quad (1)$$

where I is the perceived intensity scale reference odour concentration in ppm, P is the persistence, rate of intensity change with dilution, C is the odour concentration or dilution ratio, and k is the odour's intensity undiluted or at full strength.

For example, Fig. 1 illustrates the persistence curve for odour A and odour B, where odour B is more persistent than odour A. Thus, as the perceived intensity-dilution slopes become more horizontal, odours become more persistent.

An odour intensity referencing scale (OIRS) is used to measure the perceived odour intensity, 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 and McGinley (2000). An important aspect in the training of odour assessors is to determine if the specified concentration of the OIRS is reliable and repeatable. In a recent study, the relationship between the perceived intensity of the headspace of standard 8-point OIRS 60-mL training jars containing n-butanol and the corresponding n-butanol odour concentration (OU/m^3) was determined (Segura and Feddes 2010). This relationship is as follows:

$$C = 0.08\ B^{1.29} \quad (R^2 = 0.97) \quad (2)$$

where C is the odour concentration of n-butanol (OU/m^3) and B is the headspace concentration of n-butanol (ppm).

The high correlation coefficient value indicates that n-butanol is a reliable reference odour for training panelists. The equations cited in the literature do not relate the intensity and concentration for n-butanol concentrations below 60 OU/m^3. However, Eq. 2 is able to predict odour concentrations as low as 2 OU/m^3 (Segura and Feddes 2010).

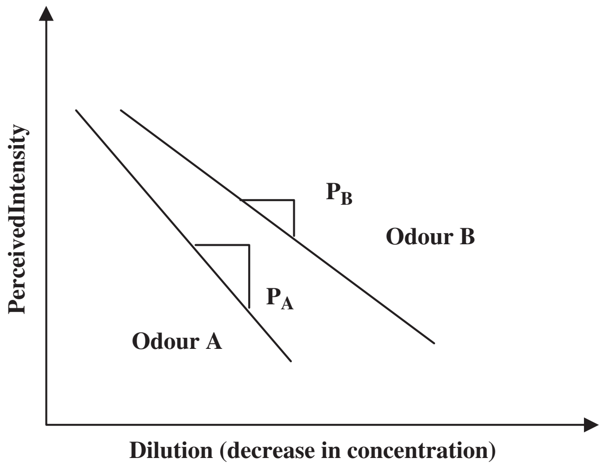

Fig. 1. Perceived odour persistence (P).

Each odour has a different persistence value. As odours are diluted, their perceived intensity decreases at different rates and consequently require a different number of dilutions to reach the geometric dilution threshold (GDT) value. If an odour intensity value is known, the odour persistence value determines the dilutions required to reach the GDT value. These values need to be included in odour dispersion models since persistence of odours affects the distance required to dilute the odour to a desired concentration.

All the odour source persistence curves intersect their GDT, which is defined as the equivalent of 0.040 ppm n-butanol or 1 OU/m^3 (BSI 2003). This is the concentration that 50% of the odour panelists can detect (BSI 2003). Researchers can measure the intensity of livestock odours with the different available OIRS ranges of n-butanol intensities (ASTM 1999). By converting the OIRS headspace concentration values to an intensity measurement (OU/m^3) with Eq. 2, the intensity or persistence measurements can be standardized.

The overall objective of this study is to include odour persistence values in the prediction equations used to determine minimum distance separation between an odour source and a neighboring receptor. The objective of this study was to measure the odour persistence from seven odour sources: broiler manure; layer manure; dairy manure; swine manure; and exhaust air from pig gestation, nursery, and finisher facilities. These values were compared to the persistence value of n-butanol.

MATERIALS and METHODS

The University of Alberta olfactometer was used to determine the dilutions required to reach the GDT value and the persistence values for the seven odour sources: broiler manure at time of cleanout, layer manure after 1 wk of storage, dairy manure from tie-stall barn, swine manure (4-wk indoor storage), gestation exhaust air, nursery exhaust air and finisher exhaust air (Feddes et al. 2001). The odour source and materials were collected from the swine, poultry and dairy facilities at the University of Alberta Edmonton Research Station. The odours were collected in flushed Tedlar bags by creating a vacuum outside the sampling bag in a sampling container. The manure samples were placed in 20-L vented containers. Odour samples were drawn from the air exhausted from the container. The olfactometer was operated to provide nine dilutions as follows: 1:16000, 1:8000, 1:4000, 1:2000, 1:1000, 1:500, 1:250, 1:125 and 1:63. Dilution values below 1:63 were not considered since these dilutions would likely contaminate the olfactometer. Eight odour assessors were recruited and trained to measure the number of dilutions at GDT and to measure the perceived intensity of the odour (scale value 1 to 8) for every dilution of source odour presented. Two 8-point OIRS training sessions were conducted using the 8-port olfactometer to present the OIRS n-butanol concentrations to all 8 panelists simultaneously (Segura and Feddes 2010). Odour panelists were trained and tested on these concentrations as described by ASTM (1999). The olfactometer port flow rate was 20 L/min for both the GDT and perceived intensity measurements. For each of the seven source dilutions, the number of dilutions required to reach GDT and the intensity (scale 1 to 8) were determined. Each intensity measurement (scale value 1–8) was converted to an equivalent n-butanol concentration (Eq. 2). Each perceived intensity measurement occurred over a 15 s interval. A pause between dilution ratio presentations of 2 min ensured that nasal fatigue was minimized. A typical odour assessor session would be conducted over a 2-h period. Each one of the nine odour sample dilutions was presented to each panelist for a 5 s period and the OIRS value and the dilution number were recorded. If required, a panelist was allowed to repeat a sniffing session of 5 s to confirm their intensity assessment. The 8-port olfactometer hardware was programmed to present randomized odour dilution ratios to the odour panelists. The procedure was found to be a reliable method to determine the persistence of the seven odour sources.

For each odour source, the persistence values were obtained in a number of steps. First of all, the GDT value was determined. Then the OIRS – number of dilutions relationship was determined (Table 1). Each slope value determination was replicated three times.

The odour persistence of n-butanol was determined from an available 46.3 ppm gas cylinder of certified n-butanol gas in a nitrogen carrier gas (Linde Canada, Mississauga, ON). A similar experimental protocol was

Table 1. Persistence values for livestock, poultry and reference odours.

Source	Persistence	R^2
Swine manure (non disturbed)	−0.87	0.86
Finisher exhaust air	−1.04	0.85
Dairy manure	−1.21	0.95
Gestation and farrowing exhaust air	−1.27	0.95
Broiler manure	−1.51	0.90
Layer manure	−1.52	0.91
Nursery exhaust air	−1.59	0.94
46.2 ppm N-butanol	−1.00	1.00

used to that of the seven odour sources. Again, nine dilutions of this gas were presented to the odour assessors to determine the GDT and perceived intensity measurements. The persistence value was found to be -1. This agrees with the theoretical persistence value of -1 (Table 1). The olfactometer diluted the 46.3 ppm by a factor of 1000 to reach the GDT value 20–80 ppb n-butanol (BSI 2003).

RESULTS and DISCUSSION

The persistence slopes for the seven odour types: broiler manure, layer manure, dairy manure, swine manure, along with gestation exhaust air, nursery exhaust air, and finisher exhaust air were obtained from the odour assessor sessions. The persistence slope values of the odour sources are presented in Table 1. The values ranged from -0.87 for swine manure to -1.59 for the nursery exhaust air. Of interest was how these values related to the slope value of -1 for n-butanol. Although n-butanol gas has a different odour character from that of livestock odours, its persistence was similar to that of the exhaust air from pig finisher facilities. The higher the persistence value, the more persistent the odour is for a similar number of dilutions.

The persistence values also have implications for determining minimum separation distances (MDS) between the source and the receptor. Sources with higher persistence values would have higher MDS values since more dilutions are required to reach a desired concentration at the site of the receptor. Odour dispersion models need to include these persistence values to reliably predict MDS values.

CONCLUSIONS

(1) Persistence values of livesock and poultry odours ranged between -0.87 for stored swine manure and -1.59 for exhaust air from a pig nursery building.
(2) Swine odours and dairy manure odour were the most persistent.
(3) Odour dispersion models need to include persistence values to determine MDS values.
(4) The persistence of n-butanol is similar to that of the exhaust air from pig finisher facilities.

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