Monitoring of odour occurrence in the vicinity of swine farms by resident-observers - Part II: Impact of weather conditions on odour occurrence

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*[1]College of Engineering, University of Saskatchewan, 57 Campus Drive, Saskatoon, Saskatchewan S7N 5A9, Canada; and [2]Agricultural, Food & Nutritional Sciences, University of Alberta, Edmonton, Alberta T6G 2P5, Canada. *Email: huiqing.guo@usask.ca*

Guo, H., Feddes, J., Dehod, W., Laguë, C. and Edeogu, I. 2006. **Monitoring of odour occurrence in the vicinity of swine farms by resident-observer - Part II: Impact of weather conditions on odour occurrence.** Canadian Biosystems Engineering/Le génie des biosystèmes au Canada **48**: 6.23 - 6.29. The impact of weather conditions including wind speed and atmospheric stability on odour occurrences as reported by the resident observers in the vicinity of intensive swine farms was studied. The results indicated that the number of odour events had an inverse linear relationship with the wind speed. High intensity odours were detected at distances up to 5.8 km from the swine farms at wind speeds up to 9.4 m/s. Swine odours were detected under all atmospheric stability classes except stability class A. Most odour events (61.7%) were detected under neutral atmospheric stability class D while only 15.0% were detected under stable atmospheric conditions. Stable atmospheric conditions occurred the least in the period from May to August, yet this period had the highest number of odour events. Hence, atmospheric stability was not the main determinative factor for odour detection frequencies. Other factors, such as increased odour emissions from outside manure storage during the warm season and the increased frequency and duration of time observers spend outside of their residences, escalating the probability they would detect an odour, seem to have greater impact on odour detection frequencies. Most observers who detected a high number of odour events were located downwind of the swine farms from the directions with the highest frequencies of neutral and stable atmospheric conditions. The results of this study suggest that odour occurrences as experienced by the resident observers varied with season, time of day, location, weather conditions, and availability of the observers outdoors. All these factors need to be considered when setting odour criteria for communities neighboring intensive swine operations. **Keywords**: odour, swine, wind speed, atmospheric stability, resident, observer.

L'impact des conditions météorologiques incluant la vitesse du vent et la stabilité atmosphérique sur la présence d'odeurs telles que relevées par des observateurs résidents dans le voisinage de porcheries a été étudié. Les résultats ont indiqué que le nombre d'évènements odorants était inversement proportionnel à la vitesse du vent. De fortes intensités d'odeurs ont été détectées à des distances allant jusqu'à 5,8 km des porcheries pour une vitesse de vent allant jusqu'à 9,4 m/s. Les odeurs d'origine porcine ont été détectées sous toutes les classes de stabilité atmosphérique à l'exception de la classe A. La plupart des évènements d'odeur (61,7%) ont été détectés sous la classe D de stabilité neutre alors que seulement 15,0% ont été détectés sous des conditions atmosphériques stables. Bien que des conditions atmosphériques stables aient été présentes le moins souvent durant la période de mai à août, c'est toutefois durant cette période que le plus grand nombre d'évènements odorants ont été relevés. Par conséquent, la stabilité atmosphérique n'était pas le principal facteur déterminant pour la fréquence de détection d'odeurs. D'autres facteurs comme une augmentation de l'émission d'odeurs provenant des structures extérieures d'entreposage du lisier durant la saison chaude et une augmentation de la fréquence et de la durée des périodes où les observateurs étaient à l'extérieur de leur résidence, augmentant ainsi la probabilité de détection d'odeurs, semblent avoir eu un impact plus grand sur la fréquence de détection d'odeurs. La plupart des observateurs qui ont détecté un grand nombre d'évènements odorants demeuraient en aval des vents dominants par rapport aux porcheries dans les directions présentant les plus grandes fréquences de conditions atmosphériques neutres et stables. Les résultats de cette étude suggèrent que la présence d'odeurs perçues par les observateurs résidents varie selon la saison, l'heure de la journée, l'emplacement, les conditions météorologiques ainsi que la présence des observateurs à l'extérieur de leur demeure. Tous ces facteurs doivent être considérés lorsque des critères de détection d'odeurs sont établis pour des communautés avoisinantes de porcheries. **Mots clés**: odeurs, porcs, vitesse du vent, stabilité atmosphérique, résident, observateur.

INTRODUCTION

Conflicts between intensive livestock operations and neighboring communities over the impact of odour emissions on the air quality of the neighboring areas have been increasing. In a number of instances, such conflicts have become a barrier to the further development of the livestock industry. Due to the lack of effective and economical odour control technologies, keeping an appropriate setback distance from a livestock operation appears to be a practical measure for ensuring acceptable air quality for the neighboring areas. Due to the fact that most current setback guidelines are based on empirical data (e.g. past experience, surveys), it is necessary to develop a science-based setback distance guideline. Part I of this study (Guo et al. 2005a) has focused on the approach for determining such a setback guideline, which requires the development of acceptable community odour criteria and the development or validation of odour dispersion models. Odour occurrence monitoring in the affected areas will provide the basic information on odour dispersion in an affected area; this information will be essential for establishing odour criteria and validating the odour dispersion model.

Table 1. Pasquill stability classes (Pasquill 1961).

Wind speed (m/s)	Daytime solar radiation			Night	
	Strong	Moderate	Slight	Thin overcast or ≥0.5 cloudiness	<0.5 cloudiness
< 2	A	A-B	B	F-G	G
2 - 3	A-B	B	C	E	F
3 - 5	B	B-C	C	D	E
5 - 6	C	C-D	D	D	D
> 6	C	D	D	D	D

Weather conditions are the most important factors that affect odour dispersion; other factors include source of odour emission, the receptor's distance and direction from the source, topography, and the odour sensitivity and tolerance of the receptors. The major weather conditions include atmospheric stability, wind speed, wind direction, temperature, relative humidity, solar radiation, and mixing height. Wind direction and speed and atmospheric stability are the dominant factors for air dispersion. The atmospheric stability classes denote atmospheric conditions that represent the amount of vertical mixing in the atmosphere. Atmospheric stability is estimated by using the Pasquill atmospheric stability classes (Pasquill 1961): A (strongly unstable), B (moderately unstable), C (slightly unstable), D (neutral), E (slightly stable), F (moderately stable), and G (strongly stable) (Table 1). Stable atmospheric conditions usually occur at night. Strongly stable atmospheric conditions (stability class G) occur during calm, clear nights when vertical mixing is nearly non-existent. Such conditions are conducive to the horizontal travel of odour and gas, therefore, odour and gas may be detected at a great distance from the emission source. Unstable atmospheric conditions usually occur during daytime. Strongly unstable weather (stability class A) occurs during hot, sunny days when rapid vertical mixing occurs. Thus, odour and gas would be dispersed rapidly and may not be able to travel great horizontal distances. Neutral atmospheric conditions (stability class D) may occur day or night with high wind speed and/or overcast sky.

In this study, community odour monitoring by trained local residents was conducted from December 2001 to November 2002 for a year around three swine production sites of a 5000-sow farrowing-to-finishing operation in a rural area of Saskatchewan, Canada. The objective was for trained resident observers to monitor the odour exposure levels in the vicinity of swine production operations. Part I of this study (Guo et al. 2005a) presented the effects of time of day, season, and location on odour occurrences and summarized the observed odour intensity and offensiveness. This paper will discuss Part II of the study, i.e. the impact of weather conditions including wind speed and atmospheric stability on odour occurrences reported by the resident observers.

MATERIALS and METHODS

The study area was located in eastern Saskatchewan, Canada (103.0°W, 51.8°N). Three separate sites of a 5000-sow farrowing-to-finishing operation were located in this area. Detailed information on the odour monitoring area, the three swine production sites, the resident-odour-observers, and data collection are in Part I of this study (Guo et al. 2005a). During the period December 2001 to November 2002, 23 families living 1.6 to 6.0 km away from the three swine production sites detected a total of 317 odour events coming from probable sources, i.e. the three swine production sites or the nearby cropland during manure application.

Meterological data measurement

A weather station was installed near the finishing site (Guo et al. 2005a). Weather data, including wind speed and direction, temperature, relative humidity, and solar radiation, were monitored once every minute and 10-minute averages were recorded. Because the weather station was not set up until April 2002, annual wind rosette and atmospheric stability distributions were generated using weather data of Yorkton, a city 68 km southeast of the study area. The Yorkton and study area is fairly flat and the difference in weather conditions was considered negligible.

Although many weather parameters may have an impact on air dispersion, wind speed and direction and atmospheric stability class are the most important factors; therefore, their impact on odour occurrences will be analyzed in this study.

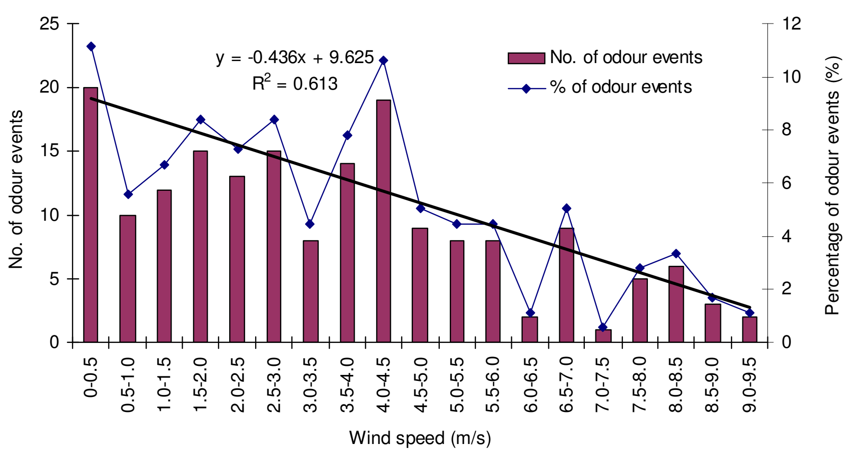

Fig. 1. Number of odour events at various wind speeds. The regression line corresponds to the number of odour events.

RESULTS and DISCUSSIONS

Impact of wind speed on odour occurrence

Figure 1 shows the number of odour events detected at various ranges of wind speed. A total of 179 odour events with available on-site wind speed data were included in this figure. The number of odour events has an inverse linear relationship with the wind speed (r^2 = 0.61); the lower the wind speed, the more odours were reported.

The total number of odour events with different intensities at various wind speeds is shown in Fig. 2. Odour events with high and

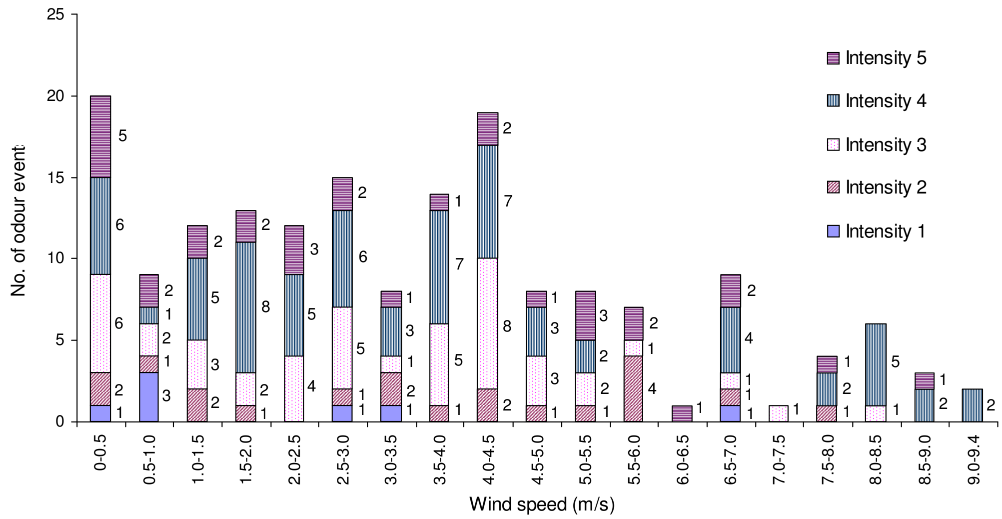

Fig. 2. Number of odour events with different intensities at various wind speeds.

Table 2. Occurrence frequencies of atmospheric stability classes during the study period.

Stability class	Average occurrence frequency (%)				
	November - April	May - October	Annual	Lowest month	Highest month
A	0.1	0.5	0.3	0.0% - December	1.1% - June
B	2.4	6.9	4.7	0.4% - December	10.9% - July
C	7.3	14.9	11.1	5.6% - December	21.0% - July
D	60.7	49.9	55.2	38.2% - July	62.5% - November
E	16.9	16.8	16.8	12.2% - June	21.7% - September
F	8.1	7.7	7.9	4.5% - February	11.0% - October
G	4.5	3.4	3.9	1.8% - June	7.0% - January

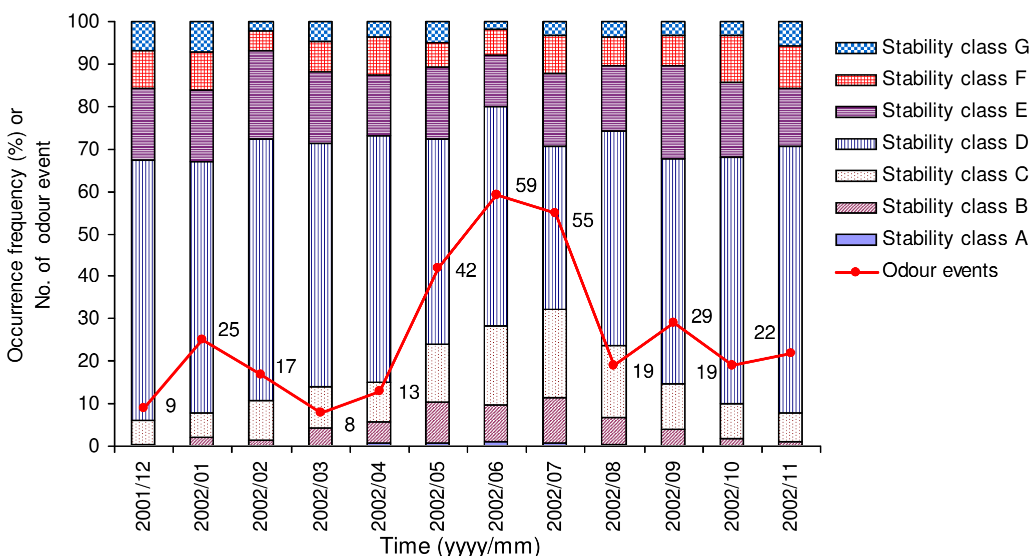

Fig. 3. Monthly atmospheric stability distributions.

low odour intensities were reported at almost all ranges of wind speeds. No specific pattern or relationship was found between the total number of odour events with a specific intensity and wind speed except that the number of odour events for all intensities generally decreased with the increasing wind speed. However, high odour intensities were reported even at high wind speeds. For instance, a total of 11 odour events were reported when wind speed was between 8.0 and 9.4 m/s. Of these events, one with intensity 3 was reported 1.6 km away from a swine site. Another one with intensity 4 was reported at a distance of 2.8 km from a swine site. The other nine events were of intensities 4 or 5 and were detected at distances ranging from 4.9 to 5.8 km away from the odour source(s). At such great distances from the swine farms, combined with high wind speeds, the odour would be much diluted and low intensities were generally expected. As discussed in Part I of this study, this again caused concern about the possible over estimation of odour intensity by the odour observers.

Impact of atmospheric stability on odour occurrence

Impact on seasonal odour occurrence Atmospheric stability data from the Yorkton weather station was used in this study. Table 2 lists annual, warm season (May to October), and cold season (November to April) occurrence frequencies of various stability classes during the experimental year. Figure 3 shows the monthly frequencies. This area was windy; stability class D had the highest annual occurrence frequency, and it generally

Table 3. Odour occurrences under various atmospheric stability classes.

Atmospheric stability class	Number of odour events by intensity					Total odour events*	Percent of odour events (by stability class)
	1	2	3	4	5		
A	0	0	0	0	0	0	0.0
B	1	2	1	3	3	10	3.4
C	3	10	20	21	5	59	19.8
D	5	25	51	77	26	184	61.7
E	2	3	9	9	9	32	10.7
F	1	0	4	1	1	7	2.3
G	0	1	2	1	2	6	2.0
Total	12	41	87	112	46	298	100
Percent of odour events (by intenisty)	4.0	13.8	29.2	37.6	15.4	100	

* Only included odour events with recorded intensities.

occurred more frequent in colder months than warm months. Stable weather (stability classes E to G) also occurred more frequently in cold season than warm season. For all stable weather conditions (stability classes E to G), the annual frequency ranged from 20.1% in June to 32.9% in January with an average of 28.8%.

Unstable weather conditions mostly occurred during the warm season from May to October with the highest occurrence frequencies in June and July, as given in Table 2 and Fig. 3. For all the unstable weather conditions (stability classes A to C), the annual average frequency was 16.3% with seasonal variations ranging between 6.0% in December and 32.4% in July.

Table 3 gives the number of odour events detected under various atmospheric stability classes. It includes only the 298 odour events with recorded intensities. Of these odours, 61.7% were detected under stability class D. During the daytime under stability class C, 19.8% of odour events were detected, which is higher than the annual occurrence frequency of stability C of 11.1%. Only 3.4% odours were detected under stability class B while no odours were reported under stability class A. Together, 23.2% of odour events were detected under unstable atmospheric conditions (stability classes A to C), which was higher than the total occurrence frequency of stability classes A to C of 16.1% (Table 2).

Fewer odour events were detected under stable weather conditions than had been expected. In fact, 10.7% of odours were detected under stability class E, and only 2.3 and 2.0% of odours were detected under stability classes F and G, respectively. Together, only 15% of odour events were detected under stable atmospheric stability classes E to G, which was lower than the total annual occurrence frequency of stability classes E to G of 28.6% (Table 2).

Figure 3 also shows the monthly odour events during the year. During May to August, unstable weather was at the highest occurrence frequency while stable and neutral weather conditions were at the lowest occurrence frequencies of the year, which indicated that this period of time was the least favorable for odour travel. However, this period had the highest number of odour events. Comparing Tables 2 and 3, it would appear that odour occurrence frequencies to some degree reflect the occurrence frequencies of various stability classes. It indicated that the atmospheric stability classes did not have much influence on odour dispersion. This would be contrary to the basic air dispersion principle that stable weather conditions would allow air to travel for farther distances than unstable weather conditions. There might be two main reasons for the observed results. First, atmospheric stability is not the sole determining factor for odour dispersion. Source odour emission rates increased during the warm season due to increased odour emissions from manure storage basins and swine barns during this season compared to the cold season. Increased odour emissions would allow odour travel for longer distances, even under unstable atmospheric conditions. Second, the occurrence frequency detected by odour observers was also determined by the availability of observers outdoors. Generally people spent more time outdoors during the warm season than during the cold season and are therefore in a better position to detect odours. Furthermore, stable atmospheric conditions occurred mostly during the night when observers were not outside to detect odours. Odour observers were most likely to be available during the daytime to detect odours that traveled to their locations, which explains the higher percentage of odours detected under stability class C. The diurnal odour occurrence will be discussed further in the next section. In summary, the odour occurrence as detected by observers indicated that source odour emissions and availability of observers for odour detection might be the dominant factors for odour detection frequencies. Thus, atmospheric stability had less impact on odour detection frequency than expected. The high percentage of odours detected under stability class D indicates that sometimes odours could travel long distances when either high wind speed or overcast conditions were present.

Impact on diurnal odour occurrence Figure 4 shows the mean cumulative occurrence frequency of each stability class in each hour period during a day in the study period. The data were obtained by cumulating the occurrences of each stability class during each hour period of every day over the year and then calculating the percentage of each stability class during each hour. With an occurrence frequency ranging from 39.9 to 72.0%, stability class D was dominant during the day and night. During the daytime, stability class C had a higher frequency (29.0%) than classes B and A (the maximum being 14.0 and 2.3%, respectively). Unstable weather with stability A to C

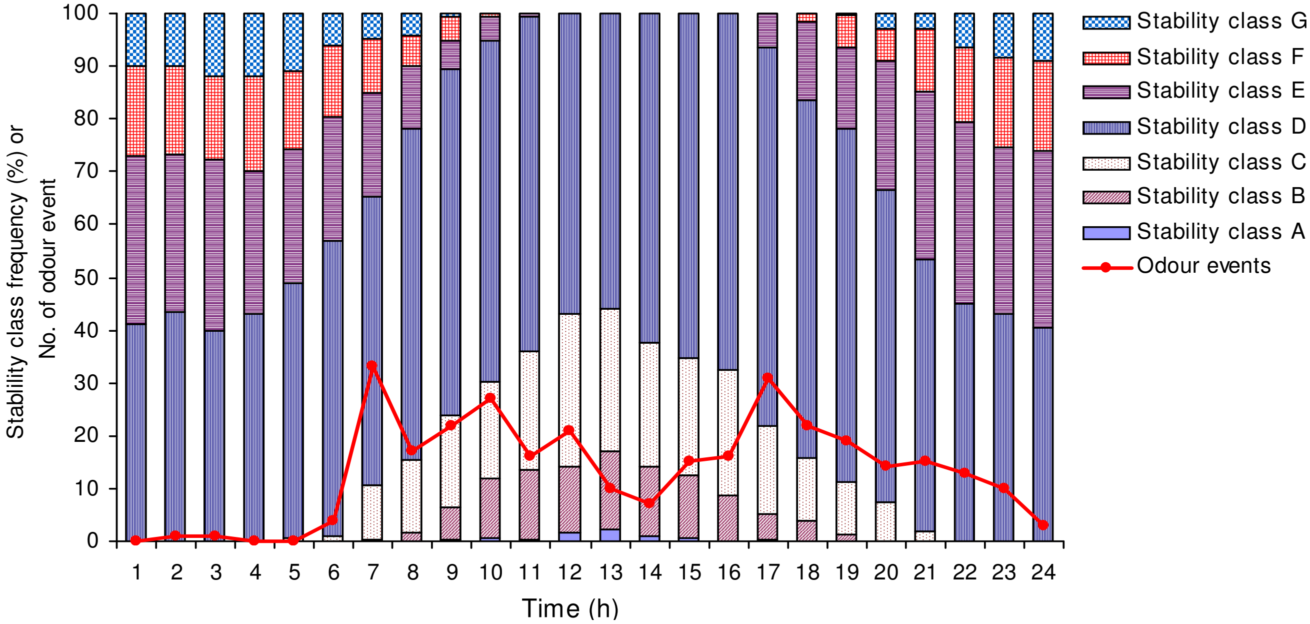

Fig. 4. Diurnal atmospheric stability distribution and detected odour events.

peaked during 1200h to 1300h with the total frequency of 44.2%. The stable weather conditions with stabilities E, F, and G occurred mostly at night with the maximum frequencies values of 34.3, 17.9, and 11.9%, respectively, which occurred between 2100 to 0400h. The overall frequency of classes E to G had a peak at 0200 to 0300h with a frequency of 60.1%. The occurrence frequency in the early morning or early evening was lower compared to that at night.

The above results indicate that stable atmospheric conditions that were favorable for odour travel occurred during the night while unstable atmospheric conditions that were unfavorable for odour travel occurred during the daytime, especially during the early afternoon period. However, as shown in Fig. 4, there was only a total of five odour events reported at night between 2300 to 0500h. The availability of observers appeared to be a more important determinative factor than weather conditions. During the daytime, although odours were not detected under stability class A and were seldom detected under stability class B, 19.8% of odour events were detected under stability class C. Under the dominant stability class D, odours occurred at any period during the daytime. The combined high occurrence of stable weather and availability of observers outside made the morning hour from 0600 to 0700h the highest period and the afternoon hour from 1600 to 1700h the second highest period of odour detection during the day. The frequency of unstable weather during the noon and early afternoon resulted in the lowest odour detection periods during the daytime.

Impact on odour intensity As indicated in Table 3, low or high odour intensities occurred under various atmospheric stability classes ranging from B to G. Odour events with intensity 1 (very faint) and 2 (faint) only constituted 17.8% of all odour events. Odour intensities 4 and 5 constituted 53.0% of all odour events while intensity 3 made up 29.2% of all. As discussed in Part I of this study (Guo, et al. 2005a), odour intensity might have been over estimated by the observers.

The observed results did not support the hypothesis that stable atmospheric conditions would favour odour travel, i.e. high intensity odours were expected to occur mostly under stable weather conditions rather than under neutral or unstable weather conditions. Odour events with intensity 4 occurred the most under stability class D (68.8%), followed by stability class C (18.8%), while intensity 5 odour events also occurred the most under stability class D (56.5%), followed by stability E (19.6%). Similarly, odour events with intensity 3 occurred the most under stability class D (58.6%), followed by stability class C (23.0%). Intensity 1 or 2 odour events occurred the most under stability classes D and C.

Under each individual stability class, except stability class E, high intensity odour events (intensities 4 and 5) occurred the most, from 44.1% under stability class B to 60% under stability class C. Under stability class E, intensity 3 odour events were detected the most frequently (57.1%) while intensity 4 and 5 odour events accounted for 28.6%. Six of the ten odour events detected under moderately unstable conditions (class B) were given intensity levels of 4 or 5 while only two of the seven odour events under moderately stable conditions (class F) were reported as intensity 4 or 5. It should be noted that the data sizes were small and the results may change with a larger data set.

Impact on odour detection distance Figure 5 shows the number of odour events detected at various distances under each atmospheric stability class. Swine odours were detected under almost all atmospheric stability classes within a 1.6 to 6.0 km radius from the production sites. It is notable that under moderately unstable conditions (class B), three odour events were reported by two observers living over 5.5 km east of the farrowing site. One observer located at 5.7 km from the source did not record the duration of the two intensity 4 odour events that he reported in June and July. Weather conditions just before the first odour detection corresponded to atmospheric stability C and then changed to B. Therefore, it may be more appropriate

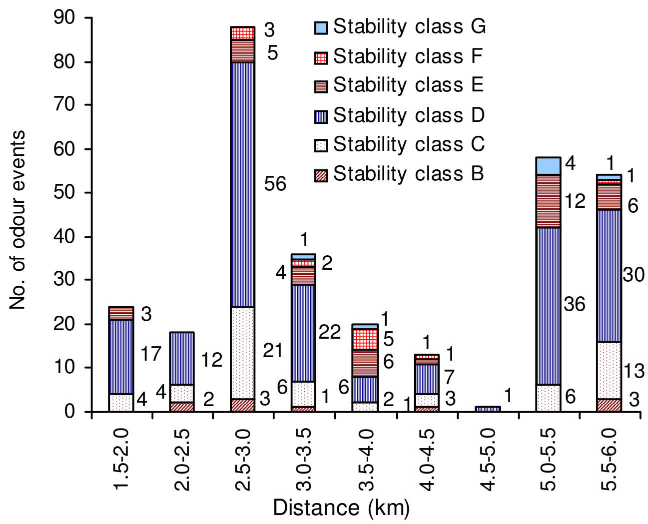

Fig. 5. Odour events under various atmospheric stability classes at different distances.

to group this event under stability C instead of B. The atmospheric stability was B before and after the second odour event was detected. Another observer located at 5.9 km from the source reported one odour event with intensity 5 that lasted for 6 hours. Right after the first detection time the atmospheric stability turned to C. There were no other known odour sources west of the observers' locations. In other words, atmospheric stability seemed have little effect on detection distance. As discussed in Part I (Guo et al. 2005a), the observers might have over-estimated odour intensity.

Impact on odour occurrence at various directions Figure 6 shows the frequencies of various stability classes as a function of wind direction. For unstable stability classes A to C, the occurrence frequencies were very low, with the maximum of A at 0.034% and B at 0.55% for winds coming from the N and S, and C at 1.2% from the S. The total occurrence frequencies of the unstable stability classes (A to C) are shown in Fig. 6a. As also shown in Fig. 6a, neutral stability class D has the highest occurrence frequencies for all wind directions compared to the other stability classes, with the highest occurrence of 7.95% from the NW, followed by WNW and W. For stable weather as shown in Fig. 6b, stabilities E and F had the highest frequencies when winds were coming from the S at 2.72 and 1.31% respectively, then followed by W and WNW winds. For stability G, the highest frequency (0.45%) occurred under west winds, then followed by winds coming from S. The total occurrence frequencies of all the stable stability classes (E to G) are shown in Fig. 6a. The highest frequency of stability classes E to G was 4.44% under south winds, followed by W and WNW wind directions. Considering both neutral and stable conditions favouring odour travel downwind from the swine sites, winds from the NW, W, WNW, and S under neutral or stable atmospheric stability had the highest occurrence frequencies of 10.2, 8.9, 8.7, and 8.5%, respectively. Therefore, the residences located SE, E, ESE, and N of the swine sites would be most frequently subjected to swine odours. The neutral and stable weather conditions occurred the least in the directions of NNE to ESE ranging from 1.8 (ENE) to 2.8% (NNE). As a result, the residences located downwind of those directions from swine sites (SSW to WNW) should experience low odour occurrences.

The observers who reported the most odour events were typically located downwind of the swine sites, corresponding to winds coming from the NW, WNW, W, and S. The observer R1, who reported the most odours, was located 3.8 km to the north of the nursery site and 3.0 km NNE of the farrowing site. Of the 79 odour events reported, 63.3% were detected between 1600 to 0900h. Most odours were detected under stability class D (62.8%) while 24.4% were detected under stability class C and 3.8% under stability class B. Only 8.9% of odours were detected under stability classes E or F. No odours were detected under stability classes G or A. Observer R3 lived 5.4 km SE of the finishing site and reported 50 odour events. However, observer R6, who was located 1.6 km SE of the nursery site and 3.3 km SW of the farrowing site, only detected 16 odour events. Observer R4 was located 5.7 km E of the farrowing site and detected 26 odour events.

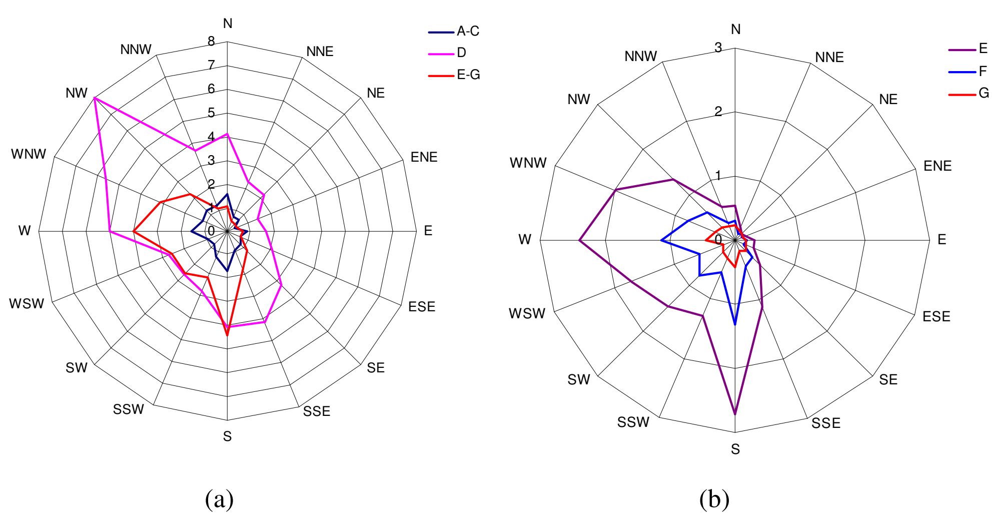

Fig. 6. Distribution of stability classes as a function of wind direction (unit: %): (a) stability classes A to C, E to G, and D; (b) stability classes E to G.

Observer R2, who recorded the fourth highest number of events, reported 21 odour events. This observer was located 3.1 km WSW of the nursery site, which was the direction that had the least number of occurrences of neutral or stable weather from the ENE direction. Observer R7, located 1.6 km W of the nursery site, reported six odour events. This again indicated that the availability of the observers for odour detection outside was very important for determining odour detection frequencies.

Comparative analysis

The results of this study indicate that odour detection frequency is determined more by seasonal factors, such as air temperature, the condition of outside earthen manure storages (i.e. liquid vs frozen surface), and residents' lifestyles, which determine the amount of time spent outside and the possibility of open windows in the home, rather than by atmospheric stability alone. The majority of the odour events (61.7%) were detected under stability class D and only 15.0% were detected under stability classes E to G. This result is quite different from the result obtained by Guo et al. (2003) in Minnesota in which 71% of odour events were detected under stable weather conditions (classes E or F) and only 16.3% under stability class D. The annual frequency of stability class D was 55.2% in the Yorkton area during the study period, which was slightly lower than the average of 61.7% from 1982 to 1990 in Minneapolis, which is the closest city to the area studied by Guo et al. (2003).

The observations made by Guo et al. (2003) found 35% of the strong odours were reported under stability class D. In this study, 65.2% of odour events with high intensity 4 or 5 were observed under stability class D. This proved again that neutral atmospheric conditions with high wind speeds could also result in strong odours. Odours were observed under unstable weather conditions, which suggested that swine odours could also travel distances of more than 5 km under unstable weather conditions.

The Atmospheric stability class and wind speed are the two important weather parameters used in setback distance determination by the OFFSET model, a setback distance model developed by Guo et al. (2005b) and Jacobson et al. (2005) regarding odour nuisance from livestock operations. The setback distance of this model was calculated using an industrial air dispersion model (Guo et al. 2005b). According to the OFFSET model, odour travels shorter distances under less stable weather conditions than more stable weather conditions, which does agree with the result obtained from the current study (within 6 km from odour sources). It needs to be further verified whether the industrial air dispersion model is capable of predicting livestock odour dispersion considering the differences of odour and gas as well as the livestock odour source and industrial air emission source.

CONCLUSIONS

Odour occurrences in the vicinity of three swine production sites were reported by trained resident observers in eastern Saskatchewan for a year. It was found that the number of odour events had an inverse linear relationship with the wind speed; the lower the wind speed, the more odour events were reported. Odours with high intensities were detected at various wind speeds up to 9.4 m/s and at a distance of up to 5.8 km from the swine farms. Most odour events (61.7%) were detected under atmospheric stability class D, while only 15% of odour events were detected under stable atmospheric conditions, and 23.2% were detected under unstable atmospheric stability classes B or C. No odour was detected under strongly unstable conditions (class A). These results were unexpected because stable atmospheric conditions generally favour odour and gas travel for long distances; therefore, odour was expected to be detected more frequently under stable than unstable atmospheric conditions. During May to August, the frequency of stable atmospheric conditions was at its lowest for the year, yet these months featured the highest number of odour events. These results indicate that atmospheric stability was not the only or even the main factor affecting odour detection frequencies. Other factors such as additional odour emissions from the outside manure storages during the warm season and the availability of observers outside of residences to detect odours (e.g. observers spent more time outside during the warm season and were unavailable during the night when stable atmospheric conditions most frequently occurred), seemed to be more important in determining the odour detection frequencies. Under each individual stability class, except stability class E, high intensity odour events (intensities 4 and 5) occurred the most, ranging from 44.1% (stability class B) to 60% (stability class C). Swine odours were detected under almost all atmospheric stability classes within a radius of 1.6 to 6.0 km from the production sites. Most observers who detected high odour events were located downwind of the swine farms along the wind directions that presented the highest frequencies of neutral and stable atmospheric conditions. In summary, the results of this study suggest that odour occurrences, as experienced by the resident observers, varied with season, time of a day, location including distance and direction from the swine farms, weather conditions, and presence of the observers outside of their residences including seasonal and diurnal lifestyles and routines. All these factors need to be considered when setting odour criteria for communities in the areas located near intensive swine operations,.

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