Characterization and Dispersion Modeling of Odors from a Piggery Facility

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Piggeries are characterized by their nuisance odors, which produce problems for workers and nearby residents. Chemical substances that contribute to these odors include sulfurous organic compounds, hydrogen sulfide, phenols and indoles, ammonia, volatile amines, and volatile fatty acids. In this work, daily mean concentrations of ammonia (NH₃) and hydrogen sulfide (H₂S) were measured with hand-held devices. Measurements were taken in several places within the facility (farrowing to finishing rooms). Hydrogen sulfide concentration was found to be 40 to 50 times higher than the human odor threshold value in the nursery and fattening room, resulting in strong nuisance odors. Ammonia concentrations ranged from 2 to 18 mL m⁻³ and also contributed to the total odor nuisance. Emission data from various chambers of the pig farm were used with the dispersion model AERMOD to determine the odor nuisance caused due to the presence of H₂S and NH₃ to receptors at various distances from the facility. Because just a few seconds of exposure can cause an odor nuisance, a “peak-to-mean” ratio was used to predict the maximum odor concentrations. Several scenarios were examined using the modified AERMOD program, taking into account the complex terrain around the pig farm.

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Abbreviations: AU, annoyance units; OTV, odor threshold value.
give an indication of the overall odor concentration. Because odor intensity is a rather unstable parameter, analytical measurements may give much different results even for samples taken from the same source but for different time intervals during the same day. Hence, the use of an apparatus that quantifies a dominant odor substance in continuous mode is preferred. Hydrogen sulfide and NH₃ are such odorous compounds often present in higher concentrations than other odors. They can be measured in very low concentrations rapidly using commercially available hand-held equipment. This is a great advantage and allows many measurements to be taken in short period of time and therefore avoiding the delay between sampling and laboratory-based measurements.

Atmospheric dispersion modeling has been applied for the assessment of odor impact using mainly Gaussian models such as the Industrial Source Complex (ISC) model (McIntyre, 2000; Henshaw et al., 2006). Dispersion modeling can be used effectively in two different ways: first, to assess the dispersion of odors and to correlate with complaints, and second, in a reverse mode, to estimate the maximum odor emissions that are permitted from a site to prevent odor complaints (McIntyre, 2000). In this case, the model output is hourly concentrations, which is a nonrepresentative time-scale, as only several seconds are enough to cause human annoyance. For this reason, a “peak-to-mean” ratio is usually used to predict the maximum odor concentrations (Piringer et al., 2007; Smith, 1973). The model AERMOD (USEPA, 2004) was used to study the dispersion of H₂S and NH₃ to the area surrounding the pig farm. The specific model has been used in many odor dispersion studies (Nicell, 2009; Hayes et al., 2006; Sheridan et al., 2004). It is a relatively easy model to use, and its characteristics (ability to use many sources and good handling of complex terrain; US-EPA, 2004) make it suitable for studying the dispersion of odors from the pig farm that was studied. Recent studies have provided relations between odor annoyance and odor exposure concentrations to express the odor impact in terms of probability of detection and degree of annoyance (Nicell, 2003; Henshaw et al., 2006; Nicell and Henshaw, 2007).

Ammonia and H₂S emissions in association with meteorological and topographical data were used as input data to a dispersion model to estimate the effects of odorous emissions in the surrounding areas. The main focus was on the specification of the parameters that need to be considered when modeling odors. These parameters are embedded in the Gaussian dispersion model AERMOD to estimate the odor impact from the facility. The methodology presented in our study indicates the need to use dose–response relationships in conjunction with dispersion modeling. This allows the estimation of the probability of detection and degree of annoyance of the communities surrounding piggeries instead of the hourly mean concentrations that AERMOD provides.

Materials and Methods

Piggery Facility

The piggery facility is located 15 km east of the city of Rethymno (Crete, Greece), in a coastal area of complex terrain, with sea to the north and hills to the south. It consists of 72 pig feeding rooms and a composting plant where the pig manure is converted for use as fertilizer. The annual production of dewatered (30% dry solids) pig manure from the pig farm operation is about 3000 Mg. In each room, pig manure is collected on the concrete floor about 40 cm below the perforated wooden floor where pigs reside. Pig manure is stored in each room for a maximum period of 5 to 9 d and then is transferred to the composting plant. Rooms are categorized according to the feeding operation (fattening or nursery) that takes place. Room dimensions differ and thus so do the ventilation requirements, with the number of constant speed fans in a room varying from 2 to 12 due to room size and feed type.

Hydrogen Sulfide and Ammonia Measurement

The most appropriate method for accurate H₂S measurement in the gas phase is the use of a gold-film monitor. These instruments utilize the change in the resistance of a gold-film sensor caused by adsorption of H₂S molecules, with an output proportional to H₂S concentration. Hydrogen sulfide concentration data were collected using a Jerome 631-X (Arizona Instruments Co., Chandler, AZ) portable analyzer capable of recording H₂S concentrations in the extended range of 1 μL m⁻³ to 50 mL m⁻³ (the units mL m⁻³ and μL m⁻³ are commonly referred to as ppmv and ppbv, respectively). The advantage of such a range enables the operator to measure H₂S concentrations in situ and assess the impact on the human odor threshold. Sample times vary depending on the H₂S concentration levels (Winegar and Schmidt, 1998). If concentration levels are in the range of 1 to 100 μL m⁻³, a time of ~20 s is required for taking a measurement. In the concentration range of 100 to 1000 μL m⁻³ time varies between 10 to 15 s. The instrument precision value corresponds to a maximum 5% relative standard deviation of the output values, ensuring at least 95% repeatability. The accuracy depends on the measuring range of H₂S. Hence, its value is equal to ±3 μL m⁻³ during the measurements taken in the first range of H₂S detection (1–100 μL m⁻³) and ±30 μL m⁻³ in the second measuring range (100–1000 μL m⁻³). The Jerome 631-X device is auto-calibrated; however, its sensitive gold-film sensor needs to be regenerated whenever it becomes saturated. The regeneration process requires only the use of AC power to thermally regenerate the sensor. When the sensor regeneration is complete, an adjustment of instrument’s zero takes place until 0 appears on the display. Then the installation of a zero air filter in instrument’s intake takes place and several samples are taken in a clean air environment to check if the measured values remain at 0 mL m⁻³. According to the manufacturer’s guide, when the sensor becomes 75% saturated, the instrument overestimates H₂S concentrations, in which case, a regeneration process is essential. To ensure a greater sensor life time and sensitivity, the sensor was never permitted to be >50% saturated in the current study. It is well known that the chemical composition of odorous emission from a piggery facility is characterized by a number of compounds. In situ quantification of all those compounds is very difficult because it requires the adoption of a reliable analytical protocol. To date, relatively little published data exist on the quantification of odorous compounds of ambient air. This is because calibrations are affected by several factors such as changes in air velocity, temperature, humidity, physicochemical properties of compounds, sampling time, sample size, and so on.
In addition, no commercial devices specializing in measuring odorous compounds at the limit of the human odor threshold value (OTV) exist, although a recently developed sorbent tube method for their measurement is very sensitive and reliable for odorous compounds from animal feeding operations (Trabue et al., 2008; Zhang et al., 2010).

Ammonia concentrations in the air were measured using a direct-sense gas meter (Gray Wolf Co., Tuamgraney, Ireland), a portable instrument with a measuring range of 0 to 500 mL m\(^{-3}\). The instrument’s sensing element is an electrochemical cell that contains a working and an active auxiliary electrode. The signal from the auxiliary electrode is used for temperature compensation and to improve the selectivity of the entire sensor. The sensor response is linear with the concentration of NH\(_3\) in air. The instrument records NH\(_3\) concentrations every 10 s, and its precision value corresponds to a maximum 5% relative standard deviation of the output values. The instrument accuracy is equal to ±0.1 mL m\(^{-3}\) if NH\(_3\) detection takes place in the range of 0 to 100 mL m\(^{-3}\) and ±1 mL m\(^{-3}\) for the measuring range of 100 to 500 mL m\(^{-3}\).

Measurements of NH\(_3\) and H\(_2\)S were taken in 62 feeding rooms within the facility, with emphasis placed on the fattening and battening processes because of their higher odor impact. To evaluate changes in NH\(_3\) and H\(_2\)S concentrations, measurements were conducted in survey mode. Each measuring period lasted for at least 10 min ensuring that approximately 60 continuous values of NH\(_3\) and H\(_2\)S were recorded. The corresponding average values were then calculated. Several measurements were conducted at the exhaust fans of nursery rooms within the facility, with emphasis placed on the fattening and battening processes because of their higher odor impact. To evaluate changes in NH\(_3\) and H\(_2\)S concentrations, measurements were conducted in survey mode. Each measuring period lasted for at least 10 min ensuring that approximately 60 continuous values of NH\(_3\) and H\(_2\)S were recorded. The corresponding average values were then calculated. Several measurements were conducted at the exhaust fans of nursery rooms within the facility, with emphasis placed on the fattening and battening processes because of their higher odor impact. To evaluate changes in NH\(_3\) and H\(_2\)S concentrations, measurements were conducted in survey mode. Each measuring period lasted for at least 10 min ensuring that approximately 60 continuous values of NH\(_3\) and H\(_2\)S were recorded. The corresponding average values were then calculated. Several measurements were conducted at the exhaust fans of nursery rooms within the facility, with emphasis placed on the fattening and battening processes because of their higher odor impact. To evaluate changes in NH\(_3\) and H\(_2\)S concentrations, measurements were conducted in survey mode. Each measuring period lasted for at least 10 min ensuring that approximately 60 continuous values of NH\(_3\) and H\(_2\)S were recorded. The corresponding average values were then calculated.

Meteorological Data

The meteorological parameters that affect the dispersion of air pollutants are air temperature, relative humidity, wind direction, wind velocity, and atmospheric stability. The data used in the present study were collected from a meteorological station (Galtee Mess-und Regeltechnik GmbH, MELA Sensortechnik GmbH, Germany) located close to the odor sources. The meteorological observations were recorded at a 30-s temporal resolution between 4 Sept. 2008 and 30 Mar. 2009. The mean temperature was 13.5°C and the mean relative humidity 66.5%. Their standard deviations were equal to 3.05°C and 9.3%, respectively. The prevailing wind direction was from the north and the wind speed ranged mainly between 3 and 9 m s\(^{-1}\), although in several cases it exceeded 18 m s\(^{-1}\). The average wind speed for the period of the measurements, which was during the early afternoon, was 4.87 m s\(^{-1}\), with a standard deviation equal to 3.8 m s\(^{-1}\), and the dominant wind direction was north (frequency 29%). These conditions are typical for a coastal area in northern Crete and are strongly affected by the landscape of the area, with the sea to the north and hills south of the site.

AERMOD Dispersion Model

The AERMOD model is a steady-state plume model. In the stable boundary layer, it assumes the concentration distribu-
compound (μL m⁻³), and γ (dimensionless) is the “persistence of response” of the specific odor. The persistence of response varies from 0 to 1 depending on the compound (Nicell, 2003). The value of the parameter γ was set to 0.4 for H₂S using observations concerning the percentage of people able to identify the existence of H₂S (Amoore, 1985). The threshold concentration is the concentration at which 50% of people exposed to H₂S can recognize its presence; it was set to 4.7 μL m⁻³ (Nagata, 1990). The corresponding value for NH₃ was set to 17 μL m⁻³ (AIHA, 1989; Nagata, 1990). Figure 1 presents the sigmoid curve that correlates the probability of detection of H₂S and its concentration. Odor threshold defines the relative position of the curve along the horizontal axis, and parameter γ is a measure of the steepness of the curve.

A similar relation has been proposed to estimate the annoyance caused by odors (Nicell, 2003) (Eq. [3]):

\[
A = 10 \left[ 1 + \left( \frac{C_{\text{SAU}}}{C} \right)^{\frac{1}{\alpha}} \right]^{\gamma}
\]  

where A (measured in annoyance units, AU) is the degree of annoyance of the population and ranges from 0 to 10, C is the concentration of the odorous compound (mL m⁻³), C_{SAU} corresponds to the odorant concentration where the population annoyance has a value of 5 AU, and the parameter α (dimensionless) is the “persistence of annoyance” of the specific odor. We estimated parameters C_{SAU} and α to be 23 μL m⁻³ and 0.68 respectively for H₂S based on observations of people being able to identify the existence of H₂S (Amoore, 1985). Figure 2 presents the annoyance with respect to H₂S concentrations. This plot is similar to the plot of the probability of detection of the specific odor, except that the point of inflection occurs at an annoyance level of 5 AU and the parameter α defines the tendency of the population to remain annoyed with the odor as it is experienced over a range of concentrations (Nicell, 2003).

**Results and Discussion**

**Fattening Rooms Measurements**

Several measurements of NH₃ and H₂S were taken in the fattening and nursery rooms. Representative measurements of NH₃ and H₂S in the fattening rooms for different operating conditions, namely, number of pigs and manure storage time, are depicted in Fig. 3. The number of pigs and the manure storage time corresponding to the measurements of NH₃ and H₂S taken in each room are given in Table 1. Average NH₃ concentrations in fattening compartment 12 varied in the range 2 to 18 mL m⁻³. The majority of the measured average values exceeded 6 mL m⁻³. Hydrogen sulfide concentrations were rather high and in some cases became 40 to 50 times higher than its OTV (4.7 μL m⁻³). The measurements that were collected on 9 Sept. 2008 in compartments 12C and 12D were characterized by increased values of NH₃ and mainly of H₂S. This was due to the longer manure storage time in these rooms (9 d). These conditions seemed to affect H₂S concentrations more than the NH₃ concentrations. Ammonia odors derive mostly from urine evaporating from the fresh wetted manure attached to the wooden floor. When urine and feces are mixed in manure slurries, the urea, found primarily in urine, is hydrolyzed by microbial ureases in feces to form carbon dioxide and ammonium (Panetta et al., 2005). The ammonium may be released as gaseous ammonia. This is the main reason that NH₃ concentrations were high under lower manure storage times. The hydrolysis of urea takes place in a very short time (6–7 d), in contrast to NH₃ formation from proteinaceous organic substances, which takes several months (Arogo et al., 2003). Despite this, NH₃ concentrations were rather high during shorter manure storage times. Therefore, NH₃ emissions derive mostly from urine evaporating from the fresh wetted manure attached to the wooden floor. In addition, manure stored for >5 d contributes to the occurrence of odor events resulting from higher H₂S concentrations. For the measurements taken on 13 Sept. 2008, compartment 12D emitted the highest quantity of odors. This may be explained by the higher number of pigs in 12D compared with 12B and 12C. However, room 12A included both the highest number of pigs and the longest manure storage time, and surprisingly, its NH₃ concentrations were lower than 12D. This was because the perforated wooden floor of room 12A was cleaned the day before measurements were taken, and therefore no excess fresh wetted manure remained except the manure already stored in the concrete floor. During the measurements taken on 10 Oct. 2008, the manure storage time was the same for each compartment.
Room 12D showed the higher values of NH₃ and H₂S because of the distinctly higher number of pigs and consequently the greater quantity of manure.

In fattening rooms 5A and 5B, NH₃ concentrations varied from 3 to 6 mL m⁻³, in contrast with rooms 12 where NH₃ exceeded 6 mL m⁻³ for almost all measurement periods of 10 min. A comparison between the values taken for compartments 5A and 5B for the same period of manure storage time found compartment 5B had a higher odor impact due to the larger number of pigs. However, both these factors significantly affected the H₂S build-up rate as seen by comparing the measurements taken on 13 Sept. 2008 and 10 Oct. 2008, with the corresponding measurements on 3 Sept. 2008. A simultaneous increase in both factors (manure storage time and number of pigs) resulted in a much higher odor impact since H₂S and NH₃ concentrations became 3 to 6 times higher. The above results suggest that the handling of odorous emissions requires a strategy for keeping both manure storage time and pig numbers within acceptable limits. In the fattening rooms with manure storage times higher than 3 d and pig numbers greater than 600, H₂S average concentrations exceed 150 μL m⁻³, which is 300 times higher than its odor threshold value. This approach cannot be adopted to limit NH₃ emissions since its concentration was not affected by the manure storage time or the number of pigs present.

**Nursery Rooms Measurements**

The average time of manure storage is usually in the range of 5 to 9 d. During the nursery stage, pigs are grown until they weigh about 50 kg, when they are then moved to the fattening rooms. To obtain a representative odorous profile, a set of experiments was conducted under almost stable conditions: manure storage time in the range of 6 to 7 d and pig numbers varying between 270 and 300 (Table 2). As indicated in Fig. 4, there was considerable variation in NH₃ concentrations; most of these exceeded 4 mL m⁻³ and in some cases they became 2 to 3 times higher. As mentioned earlier, the hydrolysis of urea takes place in 6 to 7 d. This period is the same as the period during which measurements were taken in each nursery room. The number of pigs was also at the same levels. Despite this, NH₃ concentrations were not stable, primarily due to the different frequency of room cleaning. The frequency of room cleaning is a variable parameter that depends on a room’s age and characteristics, such as the presence of perforated wooden floors. In almost every case, H₂S values were >100 μL m⁻³, and they were sometimes higher even though the number of pigs and manure storage time stayed constant. For the measurements taken on 3 Oct. 2008, there were no significant variations between the values taken for both H₂S and NH₃ in each room. For the measurements taken on 10 Oct. 2008, a slight reduction in H₂S concentration took place despite the same operating conditions. Overall, in nursery rooms for a manure storage time of 6 to 7 d and average pig numbers of 300, average H₂S concentrations exceeded 100 μL m⁻³ and NH₃ concentrations were >4 mL m⁻³. Compared with fattening rooms, nursery rooms include less animal mass and therefore less quantity of stored manure. Despite this fact, odorous emissions of NH₃ and H₂S were comparable for both kinds of rooms. The main reason is that the operation of nursery rooms takes place under higher temperatures, resulting in higher volatilization of NH₃ and H₂S. During the measurements, the average temperature values of fattening rooms were in the range 23 to 25°C in contrast to nursery rooms, where the values were always in the range 28 to 30°C, necessary for this stage of pigs’ growth.
AERMOD Dispersion Modeling of Odorous Compounds

Odorous Gas Emission Estimation

The estimation of H$_2$S and NH$_3$ emissions is essential for modeling gas dispersion since these data must be included as dispersion modeling input values. The emissions must be expressed in terms of mass flow rate (g h$^{-1}$), which derives from the odorants’ average concentration (g m$^{-3}$) and the volumetric flow rate (m$^3$ h$^{-1}$) of the emitted odorants. Because all average concentrations taken from the instruments are expressed as mL m$^{-3}$, they were converted to concentration values (g m$^{-3}$) using the ideal gas law. Volumetric flow rates of fans in the feeding rooms and the composting plant were determined by measuring the odorous gas stream velocity (m s$^{-1}$) with a specified hand-held instrument (Testo 445, Omni Instruments Co., UK) and by knowing each stack internal diameter. The instrument has the ability to compute a 15-min average of the measured values. During the measurements, the instrument was left for 15 min at each stack outlet and the average value was recorded by assuming constant flow conditions. The instrument probe measures air velocities in the range of 0.4 to 60 m s$^{-1}$, and the accuracy value is equal to ±0.2 m s$^{-1}$. According to the manufacturer, the precision value does not exceed a 2% relative standard deviation of the measured values. These measurements were conducted simultaneously with NH$_3$ and H$_2$S concentration measurements. This procedure took place at fans with the same operational characteristics to check the repeatability of the measurements. Total volumetric flow rates in each fattening room varied in the range 85,000 to 140,000 m$^3$ h$^{-1}$, and hence they were much higher than the observed rates in the nursery rooms (17,000−32,000 m$^3$ h$^{-1}$). The composting plant is divided in four different compartments (C1−C4), and each one had a ventilation rate in the range 35,000 to 40,000 m$^3$ h$^{-1}$.

The emissions were found to be higher (in some cases exceeding 40 g h$^{-1}$) at the fattening rooms and ranged from 1 to 8 g h$^{-1}$ at the nursery rooms (Fig. 5). The concentrations of H$_2$S at the composting plant were found to be below detection threshold, and NH$_3$ concentrations varied in the extended range 40 to 200 mL m$^{-3}$ during the entire sampling period. The emissions of NH$_3$ were found to be highly dependent on the type of the room, since emissions from fattening compartments were found to be about 10 times greater than those from nursery rooms. The NH$_3$ emissions from composting plant are given in Fig. 6.

AERMOD Model Predictions

The model AERMOD was applied to study the impact of NH$_3$ and H$_2$S to the area surrounding the piggery facility. At first, the model was applied to estimate the annual, monthly, and
daily average values for the concentration of H₂S and NH₃ close to the facility studied. The values calculated were lower than the detection threshold in each case, even within the facility. These results are not realistic because the characteristic odor of H₂S and NH₃ was identified several times from nearby residents and employees of the facility. Therefore, a new modified model generating results in terms of probability of detection and degree of annoyance using peak values was applied.

Using the modified model, as previously described, the results showed that the annoyance caused within the area of the facility and at a range of 2 km around it can be significant. The methodology described for H₂S is applicable for NH₃ also by altering the coefficients used according to the detection/recognition threshold of NH₃. Thus, the probabilities of detection of H₂S and NH₃ and the degree of annoyance (AU) were estimated assuming three different scenarios. The results of the simulations are presented in Tables 3 and 4 for H₂S and NH₃, respectively. The fenceline refers to the boundary of the facility and is located about 200 m from the odor sources.

Scenario 1 corresponds to the application of the modified model using the worst-case inputs (peak emissions observed). As seen, the probability of detection of the odorous compounds is rather high inside the facility (90% for H₂S and 86% for NH₃) with high degrees of annoyance (7.6 for H₂S and 8.5 for NH₃).

Scenario 2 corresponds to the application of the modified model using the same worst-case inputs as in Scenario 1; however, the stacks were assumed to be 8 m high. The stacks are used for the ventilation of the fattening and the nursery rooms, and their current height is 6 m. This parameter affects the emission height of the odorous compounds. The results indicate that both the probability of detection and the degree of annoyance have significantly smaller values. This suggests that a small change in the design of the stacks can have a significant effect on odor impact.

Scenario 3 corresponds to keeping the stacks at their current height of 6 m but reducing the NH₃ and H₂S emissions by 20%. The concentrations are significantly lower than those found using both Scenarios 1 and 2. This suggests that reducing the emissions of odorous compounds by a modest amount may also improve the current condition.

Scenarios 2 and 3 result in a decrease of both the probability of detection and the degree of annoyance of each pollutant. However, the decrease of the probability of detection of H₂S is much smaller than that of NH₃. This is due to the detection threshold of H₂S, which is much smaller than that of NH₃. On the other hand, the reduction of the degree of annoyance of H₂S is much smaller than the reduction of the degree of annoyance of NH₃ because of the “persistence of response” (γₚ) of the odor of NH₃. These parameters included in the methodology of estimation of the probability of detection and degree of annoyance through the terms \( C_{\text{sw}} \) and \( \alpha \) in Eq. [2] and [3], respectively, play an important role in the quantification of the impact of odors to the exposed population.

As there is an inherent uncertainty in the values of \( t_p \) and \( \beta \) in Eq. [1], it is important to see how sensitive the results are to these parameters. In Fig. 7, the calculated peak odor concentrations are shown with respect to distance for several
different values of the parameter $t_p$ ranging between 6 and 30 s and for three different sets of $\beta$ values. The indicated parameter value for $\beta$ is its maximum value, and it is assumed to be decreasing linearly from the source to 0.10 at 2000 m away. As seen in Fig. 7, for any given $\beta$, the shorter the period of influence ($t_p$), the longer the distance over which the peak odor concentration is above the threshold level. By increasing $t_p$ by a factor of five, the distance is reduced by a factor of two. The strength of the odor is also stronger as the period of influence is shorter.

When the maximum value of $\beta$ is changed from 0.35 to 0.45, the distance with peak odor concentrations above the threshold increases from 500 m to about 700 m. The probability of detection within these distances is always above 50%, which implies that the nuisance odors will most likely be detected within these distances.

**Conclusions**

Odorous profiles of fattening and nursery pig rooms expressed in NH$_3$ and H$_2$S concentrations revealed high and continuous odor strength of these units. The emissions of those substances, especially in fattening operations, are affected by the manure storage time and the number of pigs. Specifically, for storage times higher than 3 d and pig numbers >600, H$_2$S average concentrations exceed 150 µL m$^{-3}$. In contrast, NH$_3$ emissions showed high variability and high values (2–18 mL m$^{-3}$) and were not significantly affected by the manure storage time and the number of pigs. Nursery rooms showed a slightly lower odor impact; for a manure storage time of 6 to 7 d and average number of pigs equal to 300, H$_2$S average concentrations exceeded 100 µL m$^{-3}$ and NH$_3$ concentrations were higher than 4 mL m$^{-3}$. The difference in the levels between fattening and nursery rooms is due to the larger amount of manure excreted by the larger pigs.

In the composting plant, NH$_3$ concentrations were relatively high and varied in the extended range of 40 to 200 mL m$^{-3}$, revealing an odorous strength 10 times higher compared with the average values taken from feeding operations. Surprisingly, 90% of H$_2$S measured concentrations were zero and the remaining 10% did not exceed the 2 µL m$^{-3}$ value.

Measurements conducted outside the fenceline of the facility showed that the concentrations of H$_2$S and NH$_3$ were always below the OTV. However, the modified AERMOD predicts peak concentrations of odorants and estimates the probability of detection of a specific pollutant and the degree of annoyance of the surrounding community. The results of the simulations indicate that the annoyance caused by the presence of NH$_3$ and H$_2$S in the atmosphere close to the facility can be important during worst-case emissions–meteorological conditions. Possible solutions include increasing the height of the stacks or decreasing the emissions. Both scenarios presented significantly reduce the probability of detection and the degree of annoyance.

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Fig. 7. Effect of period of influence (t_p) on peak odor concentration versus distance from the odorous source, for three different maximum values of parameter b, which depends on the stability of the atmosphere and takes its maximum value when close to the source and diminishes to zero as the distance from the source increases significantly.


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