Technologies for Odour Management

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▪ Introduction

Intensive pork production can result in odour problems to the neighbouring population. Consequently, odours can become an environmental constraint to expanding the pig industry, especially in areas that are good for growing feed, water is available and transportation costs are reasonable. Thus, every effort must be made by the producer to reduce the **F**requency, **I**ntensity, **D**uration and the **O**ffensiveness of the odours (**FIDO**). Producers must design, construct, locate and manage the manure collection and storage facilities to minimize the FIDO.

It is unrealistic to expect a commercial hog operation to operate without some odour. However, the odour level of a hog operation can be significantly reduced when manure management systems are properly designed and operated. The exposure of barn workers and the neighbouring population to odours must be acceptable.

▪ How Odours are Generated

Odours are generated from the decomposition of the feces and urine. Over 160 compounds have been identified in odours from swine operations (O'Neil and Phillips, 1992). The principal constituents are ammonia, amines, sulphur containing compounds, volatile fatty acids, indoles, skatoles, phenols, alcohols and carbonyls (Curtis, 1993). Some of the gases are produced as manure undergoes anaerobic degradation, which occurs in the absence of oxygen. Because anaerobic degradation normally occurs at manure storage temperatures less than 20ºC, the rate of methane production is low and only products from the acid-forming bacteria predominate. These by-products are very odourous.

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Sources of Odours

Typical sources of odourous gases on pig production sites are the barns, manure storages and when manure is spread on land. Odours in barns are thought to be primarily ammonia-based since much of the fecal material and urine undergoes a drying process while stored temporarily on a solid floor or a slatted-floor surface. However, once the fecal material and urine drops into a liquid storage, the ammonia is immobilized as ammonium hydroxide in solution.

The majority of the odours in barns are thought to be generated from feces or urine deposited on solid surfaces. High odour levels in barns are also caused by low ventilation rates, poor air distribution systems or high humidity levels.

In long-term manure storages, sulphur-containing compounds such as hydrogen sulphide tend to predominate because the nitrogenous compounds remain in solution. This suggests that the odours from the buildings are different in character from outside manure storages.

Odours and People

It is difficult to quantify the effects odours have on people. This is because quite often humans respond differently to odours. A neutral odour to one may be nauseating to another. Some odours are inoffensive when weak and offensive when strong, depending on the sensitivity of a person. An odour may possess one quality when first smelled and another when smelled over time.

Sensitivity to odours changes with time of exposure. We either adapt or become sensitized. Adaptation is a reduction of responsiveness such as fatigue (Wachs et al., 1989). During long-term adaptation, a more persistent reduction in response occurs perhaps in hours or days. People who work in odourous environments usually experience this. Sensitivity may increase when a repeated, intermittent, sub-threshold stimuli induces an amplification of nerve responses such that a person may become sensitized to an odour stimulus. Historical experiences and relationships to some odours can change sensitivity and attitudes to specific odours (Frey, 1995). Thus, an odour that is initially pleasant can become a nuisance as a result of an excessive FIDO factor.

Odour Perception and Measurement

Quantifying and measuring odour is difficult because we all respond differently. Every odour sensation consists of a number of subjective odour characteristics.

Intensity and duration are the easiest characteristics to measure. The character and hedonic tone (pleasantness) of the odour are the most difficult to measure. Hedonic tone is an extremely important part of the olfactory experience since a pleasant odour to one individual may be a nauseating to another.

Generally, odours are described by intensity, concentration, character, hedonic tone, and persistence. Odour intensity is measured by comparing the intensity of an odour with a series of reference intensities of n-butanol gas. Odour character is reported by using ‘odour descriptors’ or an odour wheel. The most commonly used parameter to describe odours is concentration. It is defined as the dilution required at the detection threshold of an odour.

Odour concentration is measured by olfactometry, which consists of a human panel and an olfactometer or dilution device. Available standards suggest that a panel should consist of at least eight individuals. The individuals are pre-selected based on their ability to detect n-butanol at concentrations between 20 and 80 ppb (parts per billion) and with a certain level of consistency. In general, about 30% of the population are eligible to participate in odour panels.

Odour samples are evaluated using an instrument called an ‘olfactometer’ with an odour panel. An olfactometer is a device used to measure the dilution ratio of an odour sample at the threshold of detection. A stream of odourous air is continuously diluted with a stream of odour-free air in the device before being presented to a panel of people through a sniffing port. The panelist sniffs three sample presentations, one of which contains the odour while the other two are “blanks”. The panelist indicates to the panel leader by pushing a button, if the selection is a “guess” or a “detection”. After the first dilution level, the panelist is then presented with the next dilution level. The next dilution level presents the odour at a higher concentration by a factor of two. The panelist continues to sniff additional higher levels of sample presentation, following these methods, until the odourous sample is correctly detected by 50% of the panelists.

Human noses respond to the logarithm of odour intensity. For example, an odour source that has an odour concentration of 1000 units is reduced to 10 units by an odour control technology. This would represent a 99% reduction, however, the nose would only sense a 66% reduction (log1000= 3, log10= 1, reduction of 2/3).

Currently, research is underway to use a commercially available electronic nose to measure odour concentration in place of olfactometry. Although olfactometry is the most precise method for quantifying odours at present, using the human nose as a sensor to measure odour concentration is labour intensive, time consuming, and presents difficulty if on-site measurements are desired. Research results indicate that the currently available electronic nose can measure odour concentration with an error of about 20%. With further development, it may be possible to use the electronic nose for odour concentration measurements in place of the olfactometer. Odours could then be measured on-site with a very small labour component.

▪ The Pig Production Site

Odour intensity is greatest at the source where odours are generated. This implies that odours typically smell strongest on the pig production site. It also means that workers on the farm are exposed to the highest concentrations of odour. Worker discomfort may occur because of the intensity, duration and offensiveness of odours. This may be more evident when certain activities are conducted such as discharging manure storage pits.

▪ The Neighbourhood

As the distance between a pig production site and the neighbour increases, odour intensity and offensiveness decrease. The odours become weaker because they are diluted by atmospheric air. However, although the odours may be physically weaker relative to their strength at the source, the dilution by atmospheric air may be insufficient to dilute the odours to acceptable levels. Thus, individuals with sensitive noses who reside or conduct activities in the neighbourhood of the pig production site may still perceive the odours as strong and offensive. Often the odours are very intense during the early morning and evening hours when the windspeed is low. At low windspeeds, the odour plume appears to maintain its original shape over a few kilometres from the source.

The Minimum Distance of Separation (MDS) set out by the Code of Practice (2000) between the pig production site and residences in the neighbourhood needs to account for odour control technology and manure management practices. The method to establish MDS attempts to provide a uniform technique of assessing the conflict potential between a pig production site and the neighbouring population. It is based on livestock type, manure production, manure storage and handling system. As best management practises are incorporated into each pig production site, the hope is that the MDS will allow more pig production on each site and make room for new development opportunities.

▪ Odour Dispersion Models

The use of odour dispersion computer models (EPA, 1992) as a predictive tool is being developed. This will assist in deciding where to locate new pig operations, the acceptability of facility expansions and the degree of odour abatement required to meet acceptable odour levels at the location of potential complainants. Hopefully, in the near future, these models will be reliable enough to predict odour concentrations downwind from a pig production site along with frequency and duration. Currently, staff with AAFRD are developing a dispersion model for prairie conditions and using odour emission data collected from several sources, including manure storage trials at the Edmonton Research Station, field studies on manure storages by staff in AAFRD, and trials carried out in confinement facilities at the Prairie Swine Centre.

▪ Barn Odour Control

Odours from pig barns are generated from wet floor surfaces and to some extent from the manure storage. Building odour emission rates are considered to be continuous.

Slatted Floors

Much of the odour is produced from the surfaces (top and side) of the slats that are covered by feces and urine. If higher ventilation rates are maintained, drying will result and the odour concentration should decrease. If higher ventilation rates are used during cold weather conditions, the relative humidity will decrease in the barns and dryer conditions will occur producing less odour. Of course more supplemental heat will have to be provided. Research is ongoing to design a Tee-shaped slat with a coating that reduces the amount of manure sticking to it. This should reduce odour emissions.

Solid floor

Manure deposited on solid flooring as a result of poor dunging behaviour results in major odour emissions. The drying process of the urine (ammonia production) and the manure is very odourous along with pigs carrying much of the manure on their bodies again contributing to the odour emission.

Manure collection and storage

Manure stored in a pit beneath the slatted floor can produce hazardous odourous gases such as hydrogen sulphide. This may be released back into the room above, especially when the manure is disturbed through agitation or during pumping as the pit is being emptied. Removal on a more frequent basis reduces the emission rates of odourous gases.

Ventilating the headspace above the manure in the pit creates a higher transfer rate of odour between the manure and the animal/worker airspace.

Sprinkling Canola Oil

Sprinkling canola oil on floor surfaces is 70% effective in removing respirable dust and 40% effective in removing odour from grower/finisher facilities. Odourous substances attach to the respirable dust particles.

Biofilters

Biofilters consisting of compost-wood chip media appear to be successful at the research stage at the University of Minnesota, Manitoba and Alberta. The exhaust air from the buildings (winter ventilation rates) is ventilated through the biofilter bed located outside the building. These are normally located in the ground 1m in height.

Alternatively, the University of Alberta in collaboration with Prairie Swine Centre, Alberta Research Council and Alberta Agriculture, Food and Rural Development, is conducting research to determine the possibility of containing the odours released from the partially slatted floor area. This is accomplished by enclosing the airspace over the slatted floor area in the pen. A low capacity exhaust fan is used to draw odourous air from the enclosure and direct this air through a biofilter. The biofiltered air can be exhausted into the room or outside the barn (see figure above).

Nutrition

Many of the odourous compounds in manure appear to originate in the large intestine of the pig where undigested dietary residues are fermented by the resident microflora. Diets need to be formulated to reduce the microbial activity. The ammonia in pig housing is mainly generated by the urine as the urea volatilizes to ammonia (Aarnink 1997). The urea concentration can be reduced by improving the nitrogen utilization of the pigs' diet. According to Aarnink (1997) the protein content of pigs' diet is 3% too high. He also cites research that indicates that nitrogen excretion could be reduced by 2.5% by supplementing the diet with lysine, methionine, threonine and tryptophan and simultaneously decreasing protein content. These researchers also claimed that ammonia emissions were directly related to urinary nitrogen excretion.

▪ Manure Storage Odour Control

These storages can be very large depending on the size of the pig operation (24 m^3/sow - farrow to finish/ year). The odours generated from these sites can be quite strong and offensive, considering the sheer volume of manure undergoing decomposition.

Agitation

It is important to note that strong and highly offensive odours are generated intermittently from manure storages over the year. Factors that may be responsible for this include, loading and emptying the manure storages and effects of the weather (wind speed and direction, temperature, degree of temperature inversion).

In most cases, some form of disturbance occurs in manure as the manure storages are being loaded or emptied. The material may be agitated to obtain a consistent slurry, i.e. a homogeneous mix of liquids and solids, in order to facilitate flow through a pipe or pump. Pumping may also cause disturbance in the manure. When manure is undisturbed these gases are trapped beneath the surface, within clusters of solid material undergoing decomposition. With time the entrapped gases increase in volume and rise to the surface of the manure in a bubble. At the surface the bubble bursts and the odourous gases are gradually released into the atmosphere.

Bottom Loading

When adding manure to a pre-existing volume in a manure storage facility, it is advisable to discharge the new material beneath the surface of the manure. The discharge point should be at least 3 feet from the surface of the manure and 1 to 2 feet from the bed of solids at the bottom of the manure storage unit. This will help limit the disturbance of gases entrapped in the manure. In addition, the discharge flow rate should be low to avoid vigorous agitation of the manure.

Liquid-solids Separation

Separating the solids from the liquids prior to long term storage appears to reduce the odour emission rates. Manure can be discharged to a small volume basin where settling of the solids occurs and some of the solids float to the surface. The liquid fraction is pumped from below the surface of the basin into a 9-month earthen manure storage. At the time of emptying, no prior agitation is required because of the absence of solids. Also during storage, large mats of solids do not rise to the surface as commonly occurs and resulting in a release of attached gas bubbles. The primary cell used for settling releases little odour since the solids layer floating on the surface is dry. The solids can be removed by a backhoe on an annual basis.

Shelterbelts

One control strategy being researched today is the use of windbreaks to control odour dispersion. Other elements of the weather, which may influence the generation of odours from manure, are wind and rain. When manure has been in storage for a few days it develops a crust across its surface. This crust helps contain the release of odourous gases from the manure. However, if the crust breaks because of strong winds or heavy rain, the release of odourous gases may be enhanced.

Covers

Another promising development is the use of a geotextile sheet to cover an earthen manure storage. Air is exhausted from the space between the plastic and the manure surface. The resulting negative pressure reduces the possibility of wind gusts damaging the cover material (DGH Engineering, 1999).

Additives

Since the early 1970's the swine industry has relentlessly been exposed to a very wide variety of chemical or natural products for odour control. These products are presented as means to mitigate odours for the benefit of the farm workers and the neighbours. Some of these additives may prove helpful in liquefying the solids in liquid manure, which would be beneficial for some operations, especially to pump liquid manure out of the storage structure. So far, results have usually been disappointing on the basis of either low and unpredictable efficacy of the product, or else their high costs (Ni et al. 1999). It must be noted though that some users claim that with the use of additives the odour becomes more pleasant rather than a decrease in odour concentration.

▪ Odour Control with Land Application

There are some strategies for controlling odour emissions during land application of slurry manure. The manure may be plowed into the soil as it is being spread or it may be injected directly into the soil. Alternatively, manure may be spread on windless days or on a field downwind from sites of human activity. Consideration may also be given to morning application of manure, which allows the manure to dry thoroughly through the day (Miner and Barth, 1993). Drying helps reduce decomposition since microorganisms require moist conditions to thrive.

When slurry manure is spread on land an increase in odour intensity and offensiveness is likely to occur. This is because through spreading, the surface area from which odourous gases are released directly into the atmosphere increases. On a windy day, the effects may be more pronounced as the odour is transported from the point of application to other locations downwind from the farm.

▪ Conclusion

The minimum distance of separation (MDS) set out by the Code of Practice (2000) minimizes the conflict potential between the pig production site and the neighbouring population. When best management practices are incorporated into each pig production site, the MDS will allow more development opportunities. Best management practices include:

- Wind speed and direction taken into account when handling manure.
- Considering time of day and day of week to minimize odour exposure of neighbours.
- Minimize wet manure surfaces in barns.
- Solids should be removed from long-term outdoor manure storage.

- Reduce agitation prior to removal and gas production.
- Use bottom loading to manure storage.

Pig production sites will always generate odours, however, MDS and best management practices will ensure that the exposure to odour at the receptor site is at an acceptable level.

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