

Barn Management and Control of Odours

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▪ Introduction

Odour emissions from swine facilities are one of the most important concerns raised by municipalities and the general public regarding the pig industry. An adequate odour control strategy is a key component to establish and maintain good relationships within a new community or an existing neighbourhood.

Odour emanating from the ventilation system of a hog barn, as well as odour produced from manure storage and handling, is a significant contributor to the total farm odour emissions. In Bundy (1997), figures are presented on the justifiable complaints associated with different odour sources in swine production. Buildings were the source of 22% of the total odour complaints; slurry storage was accountable for 17%; slurry spreading for 52%; animal feed production for 8% and silage clamps for 1%.

Odour emissions from storage facilities can be controlled by the use of covers. Different types of concepts have been tested to cover manure storage facilities and reduce odour emissions: organic material (corn stalks/cobs, straw, rice hulls, peat moss), inorganic material (leka rock, oil layer), solid roofs and inflatable covers. Although many experiments have been conducted in pilot-scale tanks, some of the testing has also been done on commercial scale manure storage tanks or lagoons. Organic material such as wheat straw or corn stalks showed an important odour reduction on pilot-scale storage facilities (Bundy et al., 1997). The Prairie Agricultural Machinery Institute (PAMI) has also demonstrated that applying barley straw on manure lagoons can substantially decrease odour emissions. Prairie Swine Centre Inc. (PSCI) operates an inflatable cover for a concrete manure tank on a continuous basis. Research results indicated that this inflatable structure was efficient in reducing gas emissions from the tank.

Different manure spreading techniques have been used to lower odour emissions. Deep injection and shallow injection reduce odour emissions,

compared to not injecting, but requires more energy and larger tractors than surface application. Spreading equipment using dribble bar and curtain techniques that apply the manure close to the ground surface also reduce odour emissions. All techniques that limit the vaporisation of manure in the air and that apply it closer to the ground will provide some odour control. Therefore, different alternatives have already been identified to reduce odour emissions from storage facilities and from manure spreading.

The odour nuisance definition implicitly embodies one or more of the following quantifiable characteristics of odour:

- ▶ frequency
- ▶ intensity or concentration
- ▶ duration
- ▶ offensiveness.

For example, manure spreading is an operation that often produces an intense and offensive odour. However, its level of nuisance can be reduced by spreading the manure only once a year (low frequency) and with proper equipment that allows completing the work in a short period of time (low duration).

By its continuous operation, building odour emissions constitute a nuisance with a high frequency, duration and offensiveness. For this reason, the goal of the following discussion will mainly be to focus on building odour emissions and ways of controlling it.

▪ **Building Odour: Nature and Sources**

The sense of smell plays an important role in the human sensation of comfort. Since it is an individual character, some people will have a very sensitive nose as others will have less sensitive sniffing capabilities. Because the human nose synthesises the odour characterisation of a complex gas mixture rather than analysing each chemical compound individually, it is still the most accurate measuring device for odour measurements.

Odour in swine production is the result of a mix of various chemical substances. Those substances contribute to the odour intensity and offensiveness depending on their own odour character and concentration. Over 165 volatile compounds have been reported so far in an air sample coming from a swine facility (Miner, 1995). Most of those odorous substances can be classified into different classes of chemical compounds such as the volatile fatty acids (example: acetic, propionic, butyric acids), phenols, nitrogen derivatives (such

as ammonia, amines, indole, skatole) and reduced sulfur compounds (for example: thiols, sulfides, disulfides, thiophenes). Those chemical compounds come mainly from the degradation of the plant fibre and protein in the diet, and also from the anaerobic degradation of other more complex chemical compounds.

Within the building, odours come from the feed and feeding facilities, the pigs themselves, the floor and others surfaces (pens or building) and the manure produced by the animals. All those sources will contribute to the odour coming out of the ventilation system. As said previously, outside the building, odours will come from manure storage facilities (tanks or lagoons), from manure spreading and also from dead animal disposal.

▪ Odour Detection Techniques

Odour evaluation is an important aspect to be considered because the choice between abatement techniques, novel building designs and management practices relies on the change in odour concentration and offensiveness. Odour evaluation has been developed over the years and four techniques based on sensory odour analysis (human evaluation) are available: ranking, rating, magnitude evaluation, and forced choice dilution (Riskowski et al., 1991).

The ranking method consists of the evaluation of pairs of samples to determine the more offensive one and to place those samples in sequential order. This method is quite precise for the ranking of samples; however the differences between those samples cannot be evaluated. When using the rating method, the panelists, using a scale (generally from 0, being no odour or not offensive, to 10, being very strong or very offensive) have to assign a number to a sample. The magnitude estimation is quite similar to the ranking method with the difference that panel members are given reference points that can be used throughout the odour analysis to help evaluate the scale magnitude.

The dilution method using a dynamic forced choice olfactometer is the most recognized technique to measure odour concentration. It is used internationally and standard procedures have been developed over the years. The dynamic dilution method consists of the dilution of odorous samples with odourless air. The panelist is offered different air samples (generally three). Two air samples do not contain any odour and the third one is the odorous compound with a high dilution ratio. The dilution ratio needs to be high enough to ensure that panelists are not able to detect the odorous sample. The dilution ratio is subsequently reduced until the panelist can detect the odorous sample twice in sequence. Eight panelists are normally required for each air sample. The

odour threshold or concentration corresponds to the air dilution ratio (odourless air volume/odorous air volume) where 50% of the panelists are able to detect which port is the odorous air. For most of the dilution tests, odorous samples are taken on site and put in Tedlar bags. The analysis is then completed by panel members in the laboratory.

Some scientists have used cotton swatches to collect odour. However, a comparison study between the swatch technique and odorous samples directly taken on site showed that the swatch technique did not give reliable results for moderate to high odour concentration (Nicolai et al., 1997). In all cases using odour samples, the analysis must be done in a relatively short time period (within 48 hours from the time of collection) to prevent chemical reactions between the odorous components.

To obtain complete information on a specific odour, its intensity and hedonic tone also have to be evaluated. Two different air samples can have the same odour concentration but quite a different pleasantness (ex: food smell and pig manure smell). Odour intensity characterises an impression of odour offensiveness represented on an intensity scale. Another method that can be used to evaluate odour intensity is by comparing it to a reference odorant (1-butanol (C_4H_9OH)) presented to the panelist at various concentrations (Miner, 1995). Odour intensity can then be represented as a number from the scale or in term of 1-butanol concentration. The hedonic tone is more the qualification of the odour on a scale from extremely unpleasant to extremely pleasant (example: -4 to +4). For these evaluations, odour samples are not diluted and the olfactometer is used to present the samples to the panel.

Electronic noses have also been developed to evaluate odour level. However, this technology has yet to be improved for complex odour mixes coming from many chemical components. This technique would present interesting advantages as odour analysis could be done directly on site without a panel.

Because odour is a mix of chemical components, it must be treated as a whole when dealt with. Some attempts have been made to identify specific chemical components such as ammonia, hydrogen sulfide and fatty acids that are relatively easy to measure and which could be used as odour indicators. However, research linking chemical levels to odour levels has been inconclusive and no general correlation can be used to relate specific chemical concentration to odour levels.

▪ **Barn Odour Control**

Cleanliness and Building Design

Maintaining cleanliness of animals, floors, pens and building surfaces is a way to lower odour emissions. The soiling of surfaces with manure within the

building increases the air/manure contact area and thus increases odour emission rates. Any steps (such as frequent manure removal) that prevent anaerobic degradation of the manure within the building will lower odour emissions. From a practical point of view, this means that when a room contains dirty pens, pen scraping would reduce odour concentrations within the room and its total emission into the environment. Attention should be given to improper air distribution or drafts that would modify the dunging area, especially for barns with partially slatted floors.

For new buildings, considerations can be made to specific designs that would lower emissions: flushing gutters, limited surface gutters, or solid manure management systems. Although manure composting and deep litter systems for pig buildings have been studied, they are only applicable in particular conditions (restricted land base area for manure spreading, long transportation distances, availability of carbon sources), and more research or feasibility studies are required to apply those techniques on a large-scale basis.

Many low emissions systems have been developed and studied in Europe (ex: limited surface gutters). However, those systems would probably have to be adapted to North American conditions before being broadly implemented.

Scientists at Prairie Swine Centre Inc. (PSCI) will contribute to the evaluation of an innovative building design recently suggested by Dr. John Feddes at the University of Alberta. The proposal is to modify the configuration of the swine building to confine manure storage within the building, thus insulating the pig dunging airspace from the pig/worker airspace. When manure storage is confined within the building, traditional odour sources (building and storage facilities) are reduced to only one source: the building. In this unique example, the grower-finisher barn design will be modified to create two independent airspaces, each with an independent ventilation system. In this way, odour and gas emissions from the manure and the dunging area will be confined to this airspace and will not escape into the worker area. The exhaust air from the dunging area will be directed through a biofilter prior to being discharged into the outdoor environment. This building design is expected to reduce total odour emissions from the building and from the manure storage area improving indoor air quality for the worker. This project is conducted in collaboration with Drs. Ernie Barber at the University of Saskatchewan and Richard Coleman at the Alberta Research Council. The project conclusions will be available in fall 2000.

Dust and Odour

Dust particles found in swine buildings act as important odour carriers. Dr. Steve Hoff at Iowa State University conducted a laboratory experiment where dust particles were removed from a swine building air sample to provide

evidence of the role of dust in carrying livestock generated odours (Hoff et al. 1997a). Odour threshold was reduced for all experiments, ranging from a low of 23 % to a high of 76% for a dust particle count reduction of 47 to 98%. This means that removing particles from ventilation air can effectively result in a substantial reduction in odour. Following this preliminary study, full-scale measurements showed odour threshold reductions of 50 to 90% between the inlet and outlet of the filter when dust removal varied between 45 to 75% (Hoff et al., 1997b).

Consequently, dust particles emitted from the building ventilation system are responsible for a large portion of building odour emissions. If the dust concentration is reduced within the building, it will also be decreased at the fan level and consequently, total building odour emissions will also be reduced.

In a pig barn, dust is generated from the feed, bedding, dried manure, skin and building materials. Daily operations can have an impact on feed, bedding and dried manure. To reduce dust, regular cleaning and maintenance is required. Air circulation over dusty surfaces will return dust particles back into the air flow which will increase dust concentration. It is therefore important to periodically clean the room. Feed spillage from the feeding system or feeders must be minimised in order to reduce dust production from the feed.

In terms of the dust removal efficiency, oil/water spraying is one of the most efficient dust control techniques for livestock buildings. Two Danish systems have been developed over the last ten years and they use a mixture of water and canola oil to control the dust. From long-term observations done in different sections of a pig barn, those systems reduce respirable dust levels by 52 to 76%.

Previous work at PSCI demonstrated that sprinkling a small quantity of pure canola oil on the floor of animal buildings reduced respirable and inhalable dust by 71 and 76%, respectively. In a complementary study, a 27 and 30% reduction of hydrogen sulfide and ammonia concentrations were observed with canola oil sprinkling. The oil film presumably reduced emission rates of gases into the air, but mechanical and chemical reasons for the gas reduction need to be investigated.

A research project will be initiated at PSCI to determine the interaction of different canola oil application rates and experimental diets on odour, dust and gas emissions from swine buildings. This research, involving scientists from three Canadian provinces (Alberta, Québec, Saskatchewan), will quantify the real impact of a combined engineering and nutrition strategy to reduce odour and gas emissions from pig barns.

Dietary Manipulation, Feed and Slurry Additives

Reduction in crude protein content of the diet with adjustment to maintain essential amino acid levels results in a reduction of the nitrogen excreted by the pig. Results from different experiments show that this reduction in excreted nitrogen leads to a reduction in the concentration of selected odorous compounds (volatile fatty acids, phenols, indole). Until now, it appears that the cost of synthetic amino acids is the main factor limiting the utilisation of these diet formulations by the industry.

Many companies produce additives for use in livestock feed and manure and claim that they offer substantial benefits to producers. These benefits include reduction in odour, nutrient loss and pit gas production, and a breakdown of solids. Most of those products are clay minerals (bentonite), powdered rock (zeolite), algae, plant components (yucca extracts), bacterial and enzyme cultures, microbe nutrients and chemical products (acids). Depending on their nature, these products can be added to the feed, the manure channels or both (feed and manure). Many experiments on additives have not reported significant odour reductions. In some cases, reductions in concentration of specific chemical compounds (ammonia, hydrogen sulfide, volatile fatty acids) were measured (Barrington and Mouebbed 1995; Airoldi et al. 1993) but no direct conclusions on odour can be drawn as no direct odour measurements were taken.

Additive testing done in Minnesota (AURI, 1997) showed various levels of odour reduction in tests on eight products that cost less than 0.95 CAN\$ per marketed pig. The olfactometry technique was used to measure the effect of each product compared to an equivalent control barn. However, the protocol did not include any replication and the odour level of control barns varied widely.

Some problems arise from additive testing as procedures often differ from one lab to another and the results can hardly be compared. Also, it is difficult to assume that the products will show the same results under laboratory conditions as they would in commercial scale conditions.

Three different kinds of pit additive are being tested at PSCI in full-scale manure channels. The main goal of the study is to measure physical and chemical characteristics, and evaluate odour and gas emissions from swine manure treated with three different manure pit additives, in full-scale channels and during a one month storage period. Because the testing is completed in normal barn conditions (full-scale room and channels, continuous manure addition by the pigs), this project will provide factual information regarding the performance of pit additives for odour and solid control. The project should be completed during the winter 2000.

Bio-filters and Bio-scrubbers

Different techniques have been used to control odour as the air comes out of the building. Bio-filters and bio-scrubbers or wet-scrubbers are some of those technologies used to treat exhaust air from livestock buildings.

With a bio-filter, the exhaust air is de-dusted and pushed through an organic material (compost, peat moss, straw or crop residues, wood bark). This bedding material must be humidified and inoculated with a bacterial population. As the exhaust air comes in contact with the bedding material, the bacteria breakdown odorous and chemical compounds present in the air.

Research has included testing on pilot-scale and full-scale bio-filters. Three pilot-scale bio-filters made of a 3:1 mixture of yard waste compost with wood chips (by volume) were tested at North Carolina State University. The odour reduction measured by intensity, irritation intensity, and unpleasantness for five tests equalled 61, 58 and 84%, respectively. Low cost bio-filters are currently used in Germany on many farms (Zeisig and Munchen 1988; Hartung et al. 1997). The one developed and tested by Nicolai and Janni (1997) is showing interesting performance with odour concentration reductions in the range of 75%. Operation and construction costs of such bio-filters have been evaluated at 0.40 CAN\$ per piglet produced for a 700 sows farrowing facility.

Lais et al. (1997) present results obtained with a bio-scrubber provided with a water base. In a bio-scrubber, the exhaust air is washed with a recycled liquid (water is often used). In all cases as the air is cleaned, the liquid that is being recirculated in a closed circuit becomes charged with different chemicals or airborne particles. After a certain operating time, this sludge has to be changed and disposed of properly. Odour reduction can vary between 60 and 90%; however the cost of such technology is very high, ranging from 12.75 to 24.15 CAN\$ per market hog.

A combination of bio-filter/wet-scrubber has also been tested and no real conclusion could be drawn on odour reduction (Siemers and Van den Weghe, 1997). The air coming out had a different odour but was as strong as the one coming in for treatment. The cost associated with the combination of such techniques is 6.10 to 6.75 CAN \$ per market hog.

Bio-filtration technology appears to have a lot of potential to control odour and gas emissions from livestock buildings. Although there is no bio-filter ready for the marketplace, research results suggest that the technology will probably be feasible under real commercial conditions. Bio-filter efficiency depends on the type of bacteria, air and bedding temperatures, bedding moisture level, air flow rate, pressure drop through the bedding material, etc. The main limitation of bio-filters for livestock buildings is the bedding size required to treat the large air flow rate out of the barn ventilation system with a short retention time.

Until now, bio-scrubbers and wet-scrubbers seem to constitute a very expensive technology to install and to operate. Moreover, the out coming sludge has to be adequately managed to not create another environmental problem.

Site Selection and Management

For new swine housing projects, the choice of a site has to be done in a way to limit nuisance odours. A study of local conditions such as the prevailing winds and distances from the closest neighbours, must be done. Proper separation distances from neighbour residents generally allow for sufficient odour dilution.

A proper windbreak acts in two ways to reduce odour emissions from a production site. First, it slows down the air speed of predominant winds. In this case, the odorous air has more time to be diluted before reaching a specific distance from the site. Secondly, it increases the dilution rate of odorous compounds in the ambient air by creating more turbulence in the global airflow. Rows of threes are probably the most effective way of building such a windbreak in an esthetical and sustainable manner.

▪ Summary

Building odour emissions constitute an important contributor to the level of nuisance caused by a pig farm. Those emissions are less intense than what is produced by manure spreading, but their frequency and duration are much higher.

The nature and concentration of more than 160 compounds affect odour characteristics of an air sample collected in a swine building. Considering this complex mix of substances, the human nose is still the best instrument to characterize odours. The forced choice dynamic olfactometry method is the most accepted technique used to measure odour concentration and intensity. It requires a meticulous selection of panel members, expensive equipment and an experienced panel leader.

Different techniques have been discussed to reduce odour emissions from swine buildings. Although much research has been done, many questions remain unanswered. For example, more information is required on performance and impact on odour before new building designs, feed and slurry additives and biofilters can be recommended and applied on a large-scale basis. However, if the barn is kept very clean, the manure is removed as often as possible, an efficient dust control technique is implemented and multiphase feeding programs are used (to reduce nitrogen excretions), odour emissions

from the building are likely to be maintained at an acceptable level for the average farm community.

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