INDOOR AIR QUALITY IN PIG BUILDINGS: WHY IS IT IMPORTANT AND HOW IS IT MANAGED?

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ABSTRACT

From the first second of our lives, we need to breath fresh air. It is vital! Wherever we go, including our working place, we must have access to clean air supply. For pork producers and workers, barn environment has to provide them with fresh air to breath. Many of today's modern production facilities have the proper equipment required to control building air temperature under extreme cold conditions and also maintain a fairly comfortable environment during hot days. But considering that the majority of those systems are strictly controlled by the room air temperature, controlling the air quality in pig barns is still a good challenge. The goal of this presentation is to make producers and barn workers aware of the importance of keeping good air quality levels in their barn. This paper reviews the most important airborne contaminants present in a swine building and what should be the maximum concentration for each of those contaminants to ensure worker health and safety. Some health risks are discussed in the case where those limits are being exceeded. Various options are discussed to limit contaminant exposure in a barn environment.

WHAT DO WE MEAN BY AIR QUALITY?

First of all, it is critical to define the meaning of air quality. Under clean conditions, ambient air contains nearly constant amounts of nitrogen (78% by volume), oxygen (21%), and argon (0.9%), with varying amounts of carbon dioxide (about 0.03 %; ASHRAE 1999). Also included are trace amounts of hydrogen, neon, krypton, helium, ozone, and xenon, in addition to varying amounts of water vapour and small quantities of microscopic and submicroscopic solid matter called permanent atmospheric impurities (ASHRAE, 1993). This definition of ambient air under clean conditions could be considered as "normal air". Any other constituent than those listed is usually considered a contaminant.

The air quality is a characterization of the air content compared to its normal composition under clean conditions. In other words, the air quality is an assessment of how many contaminants (particulates, vapours) are present in addition of the various gases constituting normal, clean air. The more contaminants present in the air, the lower the air quality is.

CONTAMINANT CONCENTRATIONS MEASURED IN PIG BUILDINGS

Air contaminants in pig barns include dust particles, various gases and micro-organisms often referred to as "bioaerosols". Dust is generated from feed, bedding, dried manure, skin debris and building materials (Maghirang et al., 1995). Gases are predominantly produced directly by animals and excreta while micro-organisms are released from animals and dirty surfaces (Hartung, 1993). The most important gases are carbon dioxide (CO_2), ammonia (NH_3), hydrogen sulphide (H_2S), methane (CH_4), nitrous oxide (N_2O) and some trace gases (aldehydes, amines, aromatics, organic acids, sulphur compounds; Hartung and Phillips 1994). Carbon dioxide is mainly produced by pig respiration while ammonia is released through the bacterial and enzymatic decomposition of nitrogen compounds contained in the excreta, especially in the urine.

Bioaerosols include bacteria, endotoxins, and molds. Gram positive bacteria make up to 72% of the bacterial isolates in dust from a grower-finisher pig building (Butera et al., 1991). Twenty two species of bacteria and fungi were isolated from dust collected from a room housing pigs compared to only six species from a similar room without pigs (Martin et al., 1996). Based on those previous studies, barn ambient air includes a large variety of micro-organisms in suspension.

Recently, a comprehensive research project documented air quality in 329 buildings in Europe (Takai et al. 1998; Groot Koerkamp et al. 1998; Seedorf 1998). Overall, mean inhalable and respirable dust concentrations were 2.19 and 0.23 mg/m^3 in pig buildings and mean ammonia concentrations varied from 5 to 18 ppm. Daily mean inhalable endotoxin concentrations were 114.6, 186.5 and 135.1 ng/m^3 for sows, weaners and grower-finisher sections, respectively. The indoor concentration of total bacteria averaged 5.1 log CFU/m^3 in pig buildings. Cormier et al. (1990) found that the predominant micro-organisms in farrowing and growing-finishing units were bacteria (up to 1.25 x 10^6 CFU/m^3) with an important fraction in the respirable size range (up to 0.5 x 10^6 CFU /m^3). They concluded that air of swine confinement buildings is highly contaminated with bacteria, yeast and moulds at a level up to 1200 times higher than so called "normal air". Similar studies realised at the University of Saskatchewan have shown similar high levels of contaminants in pig and poultry buildings throughout the Prairies.

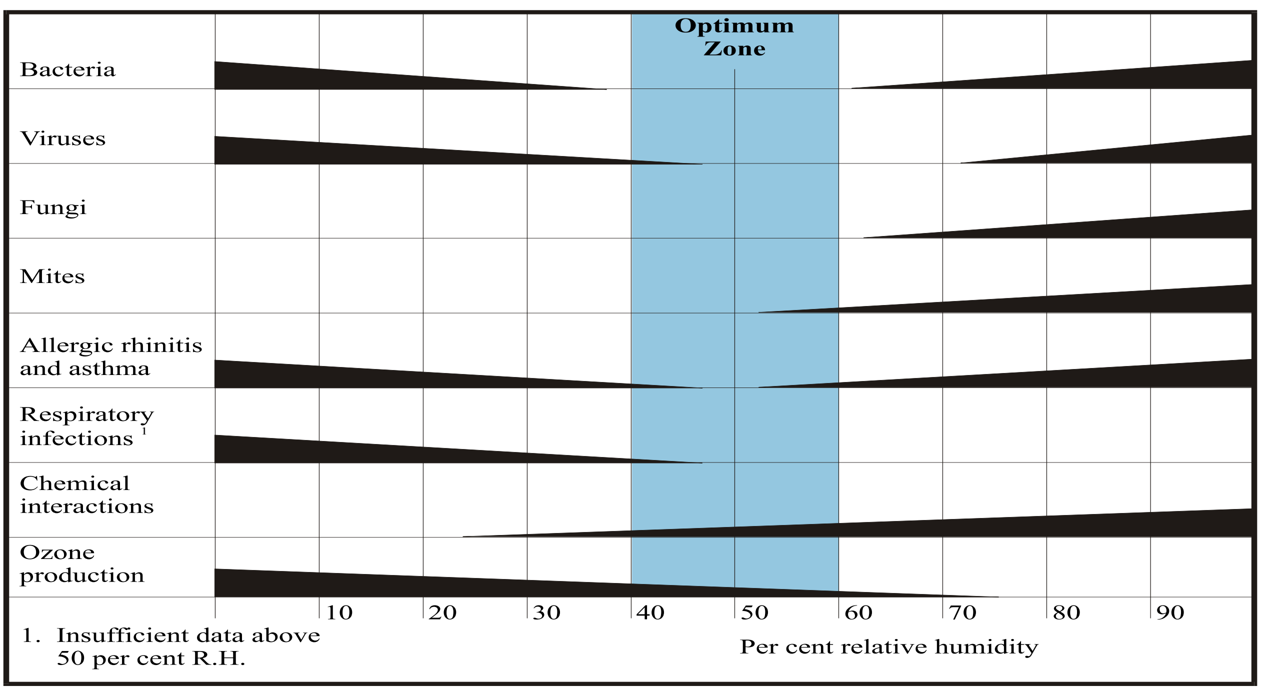
In general terms, total dust mass concentration in swine buildings will stay between 2.0 and 3.0 mg/m^3 in various sections of the barn and over the year. Dust fractions also need to be characterized based on particle size as particles of different sizes have different impacts on humans. Generally speaking, dust particles having an aerodynamic diameter larger than 0.5 μm (1 μm is 1 million times smaller than a meter) are defined as inhalable dust because they can be inhaled by the upper respiratory tract of a person. A large portion of those particles will stay trapped in the nose or the throat. Respirable dust particles that have an aerodynamic diameter between 0.5 and 5.0 μm will travel deeper into a person's respiratory system. Being so small, those particles can transport micro-organisms or gas molecules very deep into the lungs and have a combined impact as lungs are exposed to more than one contaminant type. Therefore, reducing large dust particles in the air will not always reduce the amount of airborne small particles. For example, putting oil into pig diets reduces large dust particles but it may increase respirable dust. In this case, the barn looks cleaner however the air is not safer for worker lungs.

Carbon dioxide concentration may exceed 4000 ppm under winter conditions but will normally be lower than 1000 ppm in summer time. The same trend can be observed with ammonia. Its concentration can be between 20 and 30 ppm under winter conditions but it is much lower during the summer.

Under normal barn management when the pits are emptied frequently, the concentration of hydrogen sulphide, methane and other gases will be very low from a human safety perspective. Hydrogen sulphide is mainly released when pig manure that has been stored under anaerobic conditions and is agitated in any way. Methane will be produced when liquid manure kept in storage for a long time is maintained in anaerobic conditions. Therefore, it is only under specific manure management conditions that those gases will be released and measured at high concentrations.

Relative humidity, although not a contaminant in itself, is a very easily measured component in the air that can be used to determine if there are other potential contaminants. Figure 1 shows the optimum range for relative humidity considering the growth and viability of various micro-organisms. This optimum zone is not going to be same for different building types.

Figure 1: Relative humidity and concentrations of selected air contaminants for human building occupancy



E.M. Sterling, Criteria for Human Exposure to Humidity in Occupied Buildings, 1985 ASHRAE

EXPOSURE LIMITS AND HEALTH RISKS

Different exposure limits have been defined to provide guidelines and protection to workers. Until now, for gases, these exposure limits are the same regardless of the work place and type of activities. As occupational health and safety is under provincial jurisdiction, the limits may vary slightly within the country. The values and information presented here for gases are provided by the Canadian Centre for Occupational Health and Safety (CHEMINFO, 2000).

Table 1 presents the exposure limits for gases that are most commonly present in swine buildings and can present a threat to human and animal health. The vapour density of gases relative to air (value is 1) is also presented. Gases with a vapour density higher than 1 will have a tendency to stay concentrated at floor level, under the slat, or at the bottom of enclosed areas thus replacing oxygen when their concentration is high (ex: carbon dioxide and hydrogen sulphide). The limits are given for three different exposure levels to provide enough information to the workers and give insight on levels that should not be exceeded in order to provide a safe working environment. If those threshold levels are exceeded, measures have to be taken to improve the air quality or personally protect the worker.

Table 1: Exposure limits of various gases found in swine buildings (CHEMINFO, 2000)

Gas	Symbol	Vapour density (relative to air)	TWA* (ppm)	STEL† (ppm)	IDLH‡ (ppm)
Ammonia	NH_3	0.60	25	35	300
Carbon dioxide	CO_2	1.52	5,000	30,000	40,000
Carbon monoxide	CO	0.97	35	200	1,200
Hydrogen sulphide	H_2S	1.19	10	15	100
Methane	CH_4	0.56	Simple asphyxiant at high concentrations§ (not toxic below 50,000 ppm)		

* TWA: time weighted average for an 8-hour day and 40-hour work week exposure.
† STEL: short-term exposure limit (generally 15 min. during an 8 hour shift only if no other measurable exposure occurs).
‡ IDLH: immediately dangerous to life or health, level defined so worker can still react and escape from a given contaminated environment in case of failure of the respiratory protective equipment or engineering procedure.
§ Becomes flammable at and above 50,000 ppm and is highly explosive.

Table 2 provides the gas odour and appearance of various gases and health effects associated with them and the conditions that can present a risk on health and safety of workers. The symptoms resulting from exposure to a given gas are presented for their corresponding concentration range.

Table 2: Human health responses to various gases that can be found in swine buildings (CHEMINFO, 2000)

Gas	Appearance and odour	Concentrations (ppm)	Health responses
Ammonia	Colourless, sharp odour, pungent and irritating detected at 0.6 to 53 ppm	24 to 50	Nose and throat irritation after more than 10 min. exposure.
		72 to 134	Irritation of nose and throat after 5 min. exposure.
		Above 500	Immediate and severe irritation of nose and throat.
		Above 1500	Pulmonary edema, potentially fatal accumulation of fluid in lungs.
Carbon Dioxide	Colourless and odourless	Above 20,000 (Can displace oxygen in the air)	Can affect respiratory function and cause excitation by depression of the central nervous system.
Carbon Monoxide *	Colourless and odourless	50 and above	Mild headache.
		Above 200	Severe headache.
		Above 400	Weakness, dizziness, nausea, fainting.
		Above 1200	Increased heartbeat, irregular heartbeat.
		Above 2000	Loss of consciousness and death.
		Above 5000	Death may occur in minutes.
Hydrogen Sulphide	Colourless, rotten eggs from 0.13 to 100 ppm	Above 100	Paralyses sense of smell.
		50 and above	Marked dryness and irritation of the nose and throat. Long exposure can result in runny nose, cough, hoarseness, shortness of breath and pneumonia.
		200 to 250	Severe irritation, headache, nausea, vomiting and dizziness. Prolonged exposure can cause lung damage.
		300 to 500	The above severe symptoms. Death may occur in 1 to 4 hours.
		500	Excitement, headache, dizziness, staggering, unconsciousness and respiratory failure occur in 5 min. to 1 hour. Death can occur in 30 min. to 1 hour.
		Above 500	Rapid unconsciousness and death.

* Responses may occur at lower concentrations or more rapidly for smokers that already have carbon monoxide in their bodies and for exposed persons that have heavy physical workloads or have heart disease.

As mentioned previously, methane presents a threat to safety because of the possibility of explosion. Chances are very high that an explosion will occur before methane causes asphyxia to workers by oxygen depletion.

Gas exposure can have long-term effects on workers particularly when severe exposure occurs. Exposure to high levels of hydrogen sulphide can result in nerve tissue damage, memory loss or paralysis of facial muscles. Poisoning with carbon monoxide can result in permanent brain damage and recovery after intoxication at lower levels can cause symptoms such as headache, dizziness, vision problems, memory loss, confusion and mental problems. Long-term exposure to ammonia can result in the development of a tolerance to the irritating effect and a high exposure during an extended period of time may result in eye damage.

Dust exposure limits have been defined by Donham and Cumro (1999) after having analyzed the results of different experimental studies completed in swine and poultry facilities. Exposure limits in livestock buildings are different and lower than the limits given for other activities as dust in livestock facilities is organic and results in higher responses from humans than inorganic dust. Table 3 gives concentrations that represent exposure limits for different type of particles present in swine buildings - these limits should be considered as levels to maintain for a working week-period exposure. Short-term levels, such as STEL and IDHL, have not yet been developed.

Table 3: Exposure limits for dust found in swine buildings (Donham and Cumro, 1999)

Type of particles	Concentrations
Total dust	2.4 mg/m^3
Respirable dust (0.5< particles< 5.0 μm)	0.16 mg/m^3
Total endotoxins	614 EU/m^3
Respirable endotoxins	0.35 EU/m^3

Health responses to dust exposure will vary with individuals. Periodic and acute episodes of symptoms such as fever, headache, muscle aches and pains, chest tightness and cough can be experienced and have been reported by livestock workers and those can be labelled under the "organic dust toxic syndrome" (Donham, 1999). Also Donham (1999) mentioned many studies where livestock workers reported acute or subacute respiratory symptoms such as dry cough, chest tightness, wheezing, irritation of nose, eye and throat and stuff nose and head. Chronic symptoms, such as chronic bronchitis, occupational (non-allergic) asthma and non-infectious chronic sinusitis, can also develop after a long-term exposure to livestock dusty environment (more than 6 years).

WORKER PROTECTION PHILOSOPHIES

In any kind of contaminated working environment, the worker safety can be ensured using different approaches or philosophies that we will define as: 1) engineering control; 2) administrative control; and 3) personal worker protection. An engineering control philosophy is applicable when the use of equipment, air cleaning devices or technologies can be implemented to dilute the contaminant or clean contaminated air to bring air specifications back to acceptable levels for human exposure.

When no technology can be effectively used to clean air but the risk associated with the contaminants can be dealt with by restricting worker exposure, an administrative control can be implemented. For example, depending on the contaminant, the worker may be safe in spending 15 minutes a day in presence of the contaminant. Adjusting schedules and restricting the time exposure to a specific contaminant or contaminated area is what we call an administrative control.

In some cases, no engineering control can be put in place and the contaminant level is such that no risk can be taken in exposing the worker even by reducing the exposure time. In this situation, some protection equipment (ex.: personal respirator) should be used. Instead of cleaning the air of the whole area or room, the worker is provided with the proper equipment to safely deal with working conditions.

The occupational health and safety knowledge has mainly been developed from industrial sectors where very toxic environments are being encountered. Air quality in swine buildings is generally poor but contaminant concentrations and toxicity levels are much lower than for other industrial activities. However, pig buildings present a challenge as the ambient air is contaminated with a "cocktail" of substances (gases, dust).

LIMITING WORKER EXPOSURE TO CONTAMINANTS

DUST

Dust is one of the important contaminants found in pig barns. The following section describes different techniques to protect barn workers against dust.

Disposable mask. Wearing a disposable mask still is the best option available to barn workers to ensure long-term protection of their lungs. Workers are exposed to dust everywhere in the barn and for all the tasks they need to perform. Worn properly, a disposable mask offers good protection against dust at all time during the working day.

The efficiency of disposable respirator has been well documented for industrial applications. More recently, Dosman et al. (2000) evaluated the acute health effects of wearing a N-95 (two straps, metal nose clip) disposable respirator in a swine confinement facility on human subjects not previously exposed to a swine barn environment. The results demonstrated that a two-strap mask was helping to significantly reduce acute negative health effects in subjects in terms of lung functions and immune response. Although unproven yet, it seems reasonable for the authors to suggest that both the reduction of exposure through dust control and the use of personal protection should result in similar beneficial long-term effects, at least for most exposed workers.

To be effective, disposable masks must be properly fit on the subject (well sealed on subject face) and the worker must be willing to wear it all the time. Specific masks will fit some people better than others and the level of comfort provided by the mask is related to the person physiognomy. A conventional two-strap mask without exhaust valve will be comfortable to perform tasks that are not physically demanding. However, a mask provided with an exhaust valve would be more appropriate to use during high physical activities as less restriction for breathing would be created.

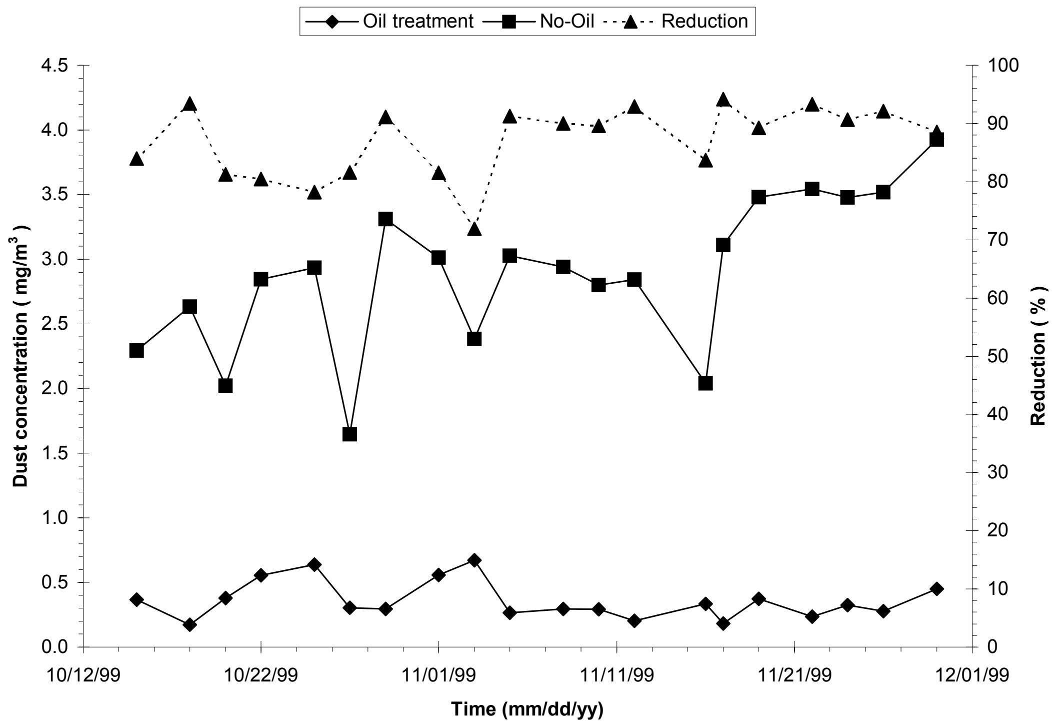
Oil sprinkling. Until now, oil sprinkling/spraying reduces dust concentration more efficiently than other techniques tested in swine buildings. By spraying a mixture of water and rapeseed oil, airborne respirable dust concentrations in pig houses were reduced by 76, 54 and 52% in long-term observations in houses for piglet, growing and finishing pigs, respectively (Takai et al., 1995). Sprinkling a small quantity of canola oil on the floor of growing-finishing rooms reduced respirable and inhalable dust by 71 and 76% (Zhang et al., 1996). In most of those previous experiments, the oil was manually applied once or twice a day.

Lemay et al. (1999) developed a low pressure sprinkling system using undiluted canola oil in grower-finisher rooms designed to control dust levels. Using recommended oil application rates for dust control (Zhang et al., 1996), the sprinkling system provided a dust mass concentration reduction of 79% compared with the control room over a two-week period. Respirable (0.5 to 5.0 μm) and inhalable (≥ 0.5 μm) dust particle counts were reduced by 73 and 80%, respectively.

The same system was tested again over a seven-week period to simulate a complete growth cycle (Lemay et al., 2000). The application rate was optimized by reducing the oil application rate compared to previous experiments and by not sprinkling operator walkways. The dust mass concentration was reduced by 87% comparing the oil treated room to the untreated room (Figure 2) and inhalable (>0.5 μm) and respirable (0.5 to 5.0 μm) dust particle counts were lowered by 90 and 86%, respectively. Compared with oil application rates recommended by Zhang et al. (1996), similar dust reduction results were obtained with a 36% reduction of the total oil usage applied over the seven-week period.

While using the automatic sprinkling system, oil needs to be applied in the pens at the following application rates: 40 ml of oil/m^2-day on the first two days, 20 ml of oil/m^2-day on the next two days, and 5 ml of oil/m^2-day on every day for the rest of the growth cycle to achieve the 75 to 80% reduction of dust concentration. Including the cost of the sprinkling system, this control technique costs less than a $1.00/pig sold.

Figure 2: Dust mass concentration in both untreated and oil treated rooms from October 15th to November 29th, 1999 (Adapted from Lemay et al. 2000)



General recommendations. The most practical option to protect barn workers against pig dust in all building sections is to use personal disposable masks. In the case where a pig producer is willing to invest some dollars to improve air quality in the barn, the oil sprinkling technique is certainly the most promising solution and is worth to be considered.

HYDROGEN SULPHIDE

As mentioned before, hydrogen sulphide is the most harmful gas that can be encountered in swine operations. When there is no manure agitation, the hydrogen sulphide concentration is generally very low in the barn. However, when manure is agitated (pulling plugs, manure flow at lift stations, manure transfer from lift station to lagoon, manure agitation in manure storage facilities), a very high quantity of hydrogen sulphide can be released.

To control the hydrogen sulfide exposure, three control philosophies can be adopted: an engineering control through sufficient ventilation, an administrative and personal protection control through the combination of standard operating procedures and proper safety equipment. Wherever the manure handling happens through out the barn (pulling plugs in rooms, manure transfer at the lift station), it is generally beneficial to have a high amount of air exchange (high ventilation rate) in the particular room or area where the procedure is performed. The person performing these tasks should be equipped with an H_2S monitor that will warn him/her if the concentration increases above the recommended levels (Table 1). Thus the ventilation rate can be manually increased until the manure handling procedure is finished. For lift stations, inlets providing fresh air to the area should preferably draw the air directly from the attic or outside as air from alleyways may have been also contaminated with hydrogen sulphide. If the hydrogen sulphide production increases because of manure agitation, the ventilation system will at least dilute the hydrogen sulphide and reduce the room concentration and worker exposure.

Standard operating procedures must be developed for manure handling in the barn to prevent worker exposure to hydrogen sulfide. As an example, each barn should clearly define an appropriate procedure for pulling plugs that may be site specific, but will ensure that people are not exposed to high levels of hydrogen sulfide while performing the task. All staff should adhere to those procedures at all times. It is also recommended to always have two persons that are properly equipped working together in this case as protective equipment can fail. Devices should be available to help workers that have to rescue his/her partner in case of distress or loss of consciousness, particularly when working in enclosed areas.

Handling the manure out of a deep pit building can produce substantial amount of hydrogen sulphide and a lot of care must be taken to ensure barn worker and animal safety. When such a large amount of manure needs to be agitated, the ventilation system should run at maximum capacity over the whole agitation process and for a sufficient period of time after the agitation is complete before anybody can be allowed to enter the building unless provided with full respiratory equipment. The same comment can be made for maintenance on manure pumps in lift stations. No one should enter an enclosed area where hydrogen sulphide may have accumulated without a full respirator.

Manure handling outside the barn represents risks as well. People have died after entering a manure tanker that had to be unplugged.

In a case of an accident, the person who is victim of hydrogen sulphide poisoning should be rescued only if the proper safety equipment is readily available. No one should try to rescue the person without respiratory protection. Too many incidents have happened where more than one person was killed trying to rescue each other. A person who has been exposed to high levels of H_2S should be taken in for proper medical care.

Different kinds of hydrogen sulphide monitors are available on the market and can be worn while working in the barn. Those instruments have alarm features and will vibrate, make noise or flash when alarm levels are exceeded. Monitoring of hydrogen sulphide should be done at all times during manure handling procedures so the worker can leave the room or enclosure if the levels are getting high. Not every barn worker needs to have one of those units but as a minimum, the person involved in manure handling should wear such a monitor at all times when performing those tasks.

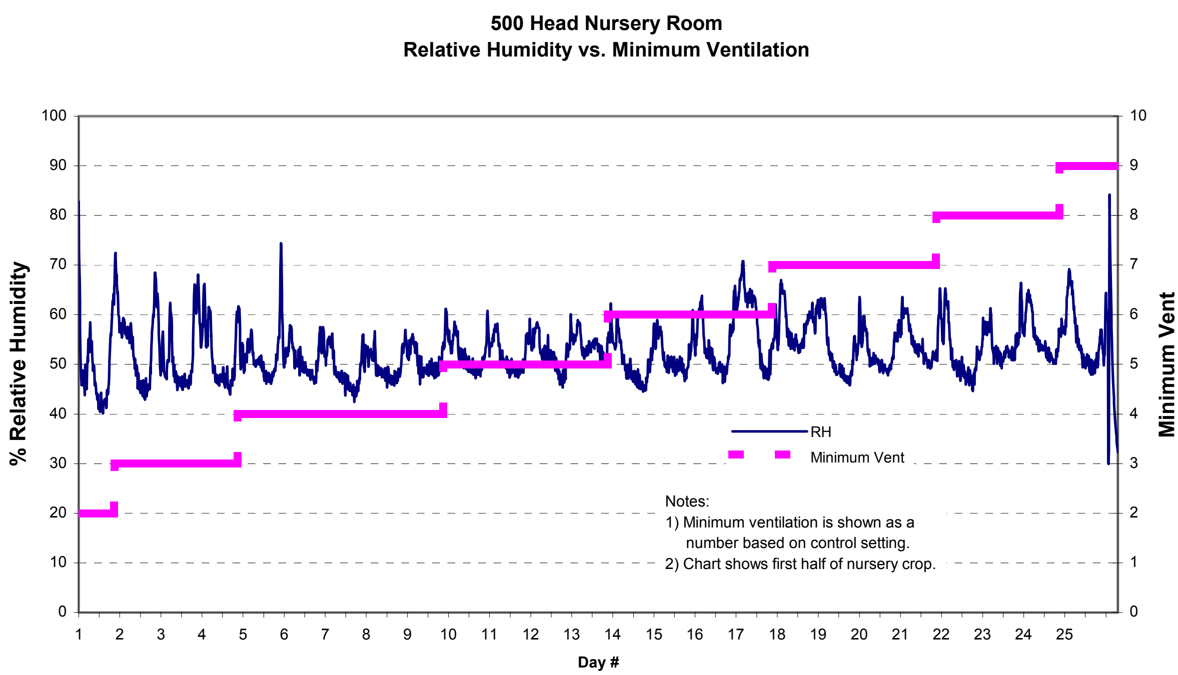
It is important to mention that manure management tasks performed in one area of the barn may result in H_2S production in other areas. Under specific conditions, pulling plugs in a room can cause other plugs to pop in other rooms and some H_2S can then be released.

AMMONIA

Minimum ventilation rate. A proper setting of the minimum ventilation rate is one of the first things to look at to maintain acceptable ammonia and carbon dioxide concentrations in a pig barn. Considering that the barn ventilation system is not controlled by the room ammonia concentration, it cannot react to an increase in ammonia release. In winter conditions and when ammonia production is controlled to a minimum (clean barn conditions, water layer into manure gutters to reduce ammonia emissions), the rotation speed of the first stage fan should be set to provide enough ventilation rate to maintain ammonia concentration below 25 ppm while controlling the relative humidity. Figure 3 shows the range in relative humidity to be expected as pig activity, time of day and outside temperature change. The solid line in this case indicates the changes in settings on the minimum ventilation rate, adjusted to keep the relative humidity within the 55% target.

If the minimum ventilation rate is set too high, the room air quality will be good but the energy consumption of the heating system will be drastically increased. A proper setting of the first stage fan should maintain gas concentrations without wasting energy.

Figure 3: Typical relative humidity graph of a nursery unit



Diet formulation. The first method to reduce ammonia emission caused by excess nitrogen is reducing the nitrogen content in diets. In the past, dietary requirements of grower-finisher pigs for each of essential amino acids were met by including enough crude protein in diets to meet requirements for lysine, the first limiting amino acid. Reduction of dietary protein combined with supplementation of synthetic amino acids in pig diets might reduce total nitrogen excretion by 25 to 40% (Jongbloed and Lenis 1993; Hartung and Phillips 1994; Kay and Lee 1997). Reduction of dietary protein by 29% resulted directly in a reduction of ammonia emission by 52% (Kay and Lee, 1997). Moreover, concentrations of other major odour components responsible for pig odour were significantly lower in slurry from pigs fed low crude protein diets compared to a control diet (Hobbs et al., 1996).

An additional method to reduce emissions caused by excess nitrogen, in particular ammonia, is by alteration of the ratio of nitrogen excretion in urine versus feces (Mroz et al., 1993). Reduction of nitrogen excretion in urine as urea, the primary precursor for ammonia volatilisation, combined with shifting nitrogen excretion into the feces, primarily as bacterial protein, will reduce ammonia volatilisation and thereby ammonia emission of swine barns. Inclusion of fermentable carbohydrates or non-starch polysaccharides (NSP) into diets stimulates bacterial fermentation in the hindgut and reduced urinary versus fecal nitrogen ratio by 68% (Canh et al., 1997a). In a subsequent study, ammonia emission was reduced up to 40% by dietary inclusion of fermentable carbohydrates (Canh et al., 1997b).

Godbout et al. (2000) have measured ammonia emissions with low protein diets and low protein diets including fermentable carbohydrates. The results indicated that diet formulation significantly reduced ammonia emission rates. In average, low protein and low protein diets including fermentable carbohydrates provided a 21 and 38% reduction in ammonia emissions from experimental chambers.

Nutrient management can have a very important impact on ammonia emissions from swine barns and on the level of exposure to ammonia workers are subjected to. More research needs to be conducted to evaluate the effect of various ingredients on emissions and to optimize diet formulations. Until now, the main limitation of implementing those diet formulations is an increase in feed cost.

CARBON MONOXIDE AND METHANE

The production of carbon monoxide in swine buildings is mainly related to poor gas combustion of the gas heaters. Gas space heaters should be well maintained to ensure that they operate with a good burning efficiency. A good burning efficiency reduces energy consumption for the same heat output and minimises carbon monoxide emissions.

Methane production will occur when pig manure is maintained under anaerobic (without oxygen) conditions for a long period of time. With a shallow pit barn, methane production is very low and it is not an issue. Deep pit barns are more likely to promote methane accumulation in the pits and those pit areas should be properly ventilated to reduce risks of explosion.

CHANGES IN THE INDUSTRY

The knowledge we have on the impact of barn air quality on human health was primarily gained on family farms where people were spending few hours a day in the barn. We do not have much information on career barn workers that spend 40 hours a week in a swine facility. We do not know yet what might be the long-term effect, if there is any, of the air quality on health status of established swine workers.

Having said that, to be responsible as an industry, we should promote the usage of disposable masks and personal monitors. As well, respiratory equipment should be available whenever it is needed. It might also be good to have a follow-up of the health status of our swine workers to ensure that there is no detrimental effect for specific individuals of working in a pig barn and that all the steps are taken to insure their good health.

Overall, more research is needed to investigate the impact of the contaminants present in pig barns. Exposure limits have been defined for single contaminants and very little information is available on the synergy of those contaminants together.

CONCLUSIONS

- The main contaminants in swine buildings are dust, hydrogen sulphide, ammonia, carbon dioxide, various micro-organisms and other gases.
- For each contaminant, there are some exposure limits to be maintained in the barn to ensure worker health and safety.
- Wearing a two-strap disposable mask is the best way of protecting yourself against pig dust and the long-term effect it might have on your lung functions.
- Hydrogen sulphide is the most harmful contaminant found in pig barns and is mainly released when swine manure is agitated.
- A proper personal respirator should be worn whenever someone needs to enter an enclosed area where hydrogen sulphide or other gases may have accumulated.
- See your physician on a regular basis to verify your personal capabilities of dealing with a barn environment exposure and keep him/her informed of your working situation.

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