Air Quality and Health of Career Pig Barn Workers

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▪ Introduction

Alberta's pork industry requires a highly skilled, stable labour force. The development and retention of a skilled workforce is dependent, in part, on ensuring a healthy working environment. Over the past 10 to 15 years, pig barns have evolved from operations in which workers were required to spend only a portion of their day in the barn, to the current situation, in many of the large intensive housing facilities, where full-time work is required. This increase in the number of hours worked per day in the barn has resulted in net increases in daily exposures for workers to air contaminants, including airborne particulates and gases.

The objective of my presentation is to:

- Increase the industry's awareness of airborne contaminants to which career pig barn workers are exposed,
- Present results from a recently completed pilot study,
- Highlight the importance of continued research into exposure assessment among this group of workers.

▪ Air Contaminants in Pig Barns

Three groups of contaminants have been associated with adverse health outcomes among pig barn workers. These include: dust, gases, and endotoxins (Reynolds, et al., 1996). Present knowledge of how these affect workers will be briefly reviewed.

Dust in Pig Barns

The dust in pig barns is primarily organic, meaning that it is highly biologically active. Some of the sources of this dust include: pig dandruff, dried fecal material and urine, feed, bacteria, endotoxins and dust mites. Dust is present in barns in a wide range of sizes, and is measured in units called 'microns'. A micron, or micrometer (μm), is a unit of length which is equal to 0.001 mm. Depending on its size, dust can be filtered out in the upper part of the worker's respiratory system, including the nose and pharynx, or it can travel deep into the lungs and be embedded in the outermost lung tissue (Figure 1). Dust particles of various sizes, present in indoor environments, are generally defined as total, inhalable, or respirable, depending on the size of the dust particle and its potential impact on the respiratory system. The visible dust that is present on penning material, on floors and walls of pig barns, tends to be made up of larger particulates. Due to their size and weight, these larger dust particles tend to settle out of the air first. Typically, dust in the larger size ranges is efficiently filtered out by the human nose and pharynx. At rest, the human nose is capable of removing most particles in a size range >20 μm, and approximately 95% of particles that are 5 μm in diameter (West, 1998).

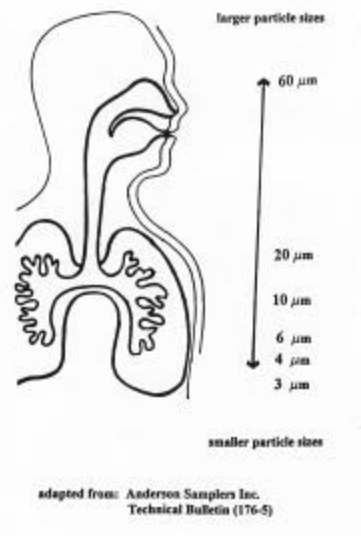

Figure 1. Penetration depth of particles

Total Dust

This category includes all airborne particles. The larger particles in this size range are visible by the human eye.

Inhalable Dust

This category refers to airborne particulates that are <100 μm in size. They can be inhaled through the nose and mouth into the respiratory system. Some of these airborne particles are trapped in the mucous of the nose and pharynx and are prevented from traveling deeper into the lungs. Particulates in the upper range of this size category can be seen with the human eye. For example, the diameter of a human hair, sand tailings, pollens, cement dust, and smaller size particles of ground limestone, can all be included in this category.

Respirable Dust

Airborne particles in this size category are < 10 μm in diameter and are easily trapped in the upper and lower airways. Mid-sized respirable particles (1- 5μm) are more likely to settle in the small airways (West, 1998). Since the particles in this size range are so small, they stay suspended in air and therefore have all the properties of an aerosol. For this reason, they are often called bioaerosols, linking both their biological activity and their "aerosol-like" properties. Knowledge of the concentration of respirable dust in pig barns is critical in assessing its impact on the respiratory health of workers. Respirable dust particles are microscopic and therefore not visible to the human eye. Examples of airborne contaminants in this size range include: spray dried milk, zinc oxide fumes, sulfuric acid mist, and insecticide dusts.

Gases in Pig Barns

The gases in the pig barn environment of greatest concern to the health of workers are ammonia (NH_3), carbon dioxide (CO_2), and hydrogen sulfide (H_2S). Gases are measured in units of parts of gas per million parts of air by volume (ppm).

Ammonia (NH_3)

NH_3 gas is produced from the drying of manure and urine on solid floor surfaces in a pig barn. Very little is produced from storage of liquid manure in the barn. Ammonia has a low odour threshold, (< 5 ppm), meaning that its presence is readily detectable. This gas is highly soluble in water and therefore irritates mucous membranes of the eyes, nose and throat (including the upper respiratory system). The ammonia gas molecule has a particle size ranging from 0.0005 μm to 0.01 μm. Researchers speculate that NH_3 gas particles may adhere to respirable dust particles, and subsequently be carried deep into the lungs. This adds to their potential toxicological effects.

Hydrogen Sulfide (H_2S)

H_2S is a by-product of the anaerobic breakdown, by bacteria, of manure. It is normally present in the pig barn environment at very low levels (< 3 ppm). However, when manure pits are agitated, lethal concentrations of H_2S can be liberated. The presence of H_2S can sometimes be detected by its "rotten-egg" smell. At lethal concentrations, however, the sensory capabilities of the nose are deadened, and the smell can no longer be detected. At low levels (10 ppm), eye irritation can result. With increasing concentrations, symptoms may include vomiting, nausea, diarrhea, dizziness, unconsciousness and, rapid death (Saskatchewan Labour, 1998).

Carbon Dioxide (CO_2)

CO_2 is present in the pig barn environment primarily as a normal by-product of pig respiration. High CO_2 concentrations are detrimental in a barn environment, since less oxygen will be present in the same environment (Dalton's gas law). CO_2 levels in the barn are used as a measure of barn air quality, and the adequacy of the barn's ventilation system.

Endotoxins

Endotoxins are components of the cell wall of gram negative bacteria and are biologically active, whether they are still a part of, or independent of, the bacterial cell (Preller, et al., 1995). Acute effects of worker exposure to endotoxins include conditions such as broncho-constriction, organic dust toxic syndrome, or mucous membrane irritation (Olenchock, 1997).

Threshold Limit Values (TLV)

TLVs are exposure limits developed by organizations such as the Occupational Safety and Health Administration (OSHA) and The American Conference of Governmental Industrial Hygienists (ACGIH). They serve as guidelines to control health hazards in work environments. Assuming that the TLVs for each contaminant present in the workplace are not exceeded, a healthy worker can work in that particular environment for 8 hours per day, over an extended period of time, without compromising health. The TLVs for contaminants discussed in this paper are presented in Table 1.

Table 1. Threshold Level Value (TLV) for dust, gases, and endotoxins

Contaminant	TLV
Dust	
Total	10 mg/m^3
Respirable	-[a]
Gases	
NH_3	25 ppm
H_2S	10 ppm
CO_2	5000 ppm
Endotoxin	-[a]

[a] *No TLV determined.*

The Pig Barn Environment - A Complex Mixture of Air Contaminants

Career pig barn workers are exposed to a complex mixture of airborne contaminants in their work environments. Each component of this mixture may independently affect worker health. However, in combination, the various contaminants may be more potent from a worker health perspective. For this reason, Reynolds, et al. (1996) suggest that lower TLVs should be established for environmental contaminants in agricultural settings.

▪ Career Pig Barn Worker Exposures

The size and complexity of today's modern pork production facilities requires full-time workers, working eight or more hours per day. In addition, for biosecurity reasons, many operations have a shower-in policy, such that workers often remain inside the barn for the duration of their work shifts. Workers who are employed in the pork industry today are highly specialized and have work responsibilities in particular areas of the barn, that house different classes of pigs. Daily job responsibilities and tasks differ among the workers in the pig barn. Workers have specific tasks that must be completed each day, and these tasks may vary during the week. Limited information exists on the career pig barn workers' daily activities and the effects these activities have on exposures to barn contaminants. Although different pig barn workers in the same barn experience different exposures, this distinction has not been made in previous studies. Furthermore, there is inadequate research on the exposures of specialty career pig barn workers to dust, gases and endotoxins.

Workers in large intensive pig facilities have previously been inaccessible to researchers due to the stringent biosecurity requirements of modern pig operations. In cooperation with specialized pig veterinarians in Alberta and Saskatchewan, a rigorous biosecurity protocol has been developed and validated, which enables exposure assessment instrumentation to be used in various pork production facilities across Alberta.

▪ The Pilot Study

The pilot study was a feasibility study, funded by the Alberta Pork Producers Development Corporation, Alberta Agriculture, Food & Rural Development, and the Centre for Agricultural Medicine, University of Saskatchewan. The funding was used to assemble and test a prototype of the personal environmental sampling backpack (PESB), and to collect workshift exposure data and

respiratory health information, during the winter and summer of 1998, from workers employed in five barns within a 200 km radius of Edmonton.

The Personal Environmental Sampling Backpack (PESB)

The PESB was designed to record exposure data, in one minute intervals, for the duration of a 9-hour workshift. The PESB monitors the following environmental parameters (Table 2):

Table 2. Parameters measured by the Personal Environmental Sampling Backpack (PESB)

Parameter	Method	Range	Error
Temperature	thermistor	-40 to +70^{o}C	± 0.2^{o}C
Relative Humidity	capacitive	0 to 100% RH @ 25^{o}C	± 2%
CO_2	non-dispersive infro-red	0 to 5000 ppm	± 5% reading
NH_3	electrochemical	0 to 50 ppm	
Dust Particle Counter	laser diode	0.3, 0.5, 1.0 & 5.0 µm	

Figure 2. PESB equipment

Figure 3. Worker wearing PESB

The PESB was designed to be portable. Various environmental monitoring systems were re-assembled into a weather-tight instrumentation box (Figure 2), which fit into a hiking backpack. The entire unit weighs 8.1 kg (18 lbs), allowing workers to wear it while performing their daily work duties (Figure 3).

Pilot Study Objectives

The objectives of the study were to:

- Determine if pork producers and their employees would understand the need for research studying the relationship between lung health and air quality in pig barns.
- Ensure that the PESB could be used on a continuous basis under adverse environmental conditions in pig barns.
- Determine if a satisfactory personal monitoring strategy could be established that would permit accurate quantification of personal exposures without interfering with normal work routines.
- Ensure that the protocol for lung health testing (including pre- and post-shift spirometry[1] and administration of a respiratory symptom questionnaire) could be accommodated within the normal workday without causing undue disturbance.
- Ensure that samples collected in the barns could be analyzed with acceptable precision.

In all cases, the objectives of the pilot study were achieved:

The worker participation rate was 100%, calculated from the number of workers asked to participate in the study, and the number who actually participated. The workers who participated in this study represented eight different specialty job classifications: farrowing, finishing, dry sow, manager, farrowing-nursery, breeding-farrowing, grower-finisher, and farrowing-finishing.

The personal environmental sampling equipment was found to adequately quantify the exposures of workers throughout the sampling day. Minor modifications were made to the PESB during the pilot study.

Generally, the PESB did not interfere with normal work routines. Most of the workers wore the equipment for the duration of their workshifts. There were certain tasks however, for which individual workers found the PESB to be too bulky and heavy. An example of this was for the moving and weighing of

[1] Spirometry is the simplest test of lung function. Participants blow into a machine, called a spriometer, which measures the total amount of air that can be blown out of the lungs.

market pigs. Therefore, for specific work tasks, a member of the study team wore the PESB, and worked alongside the study participant.

The respiratory health assessment tools used in the pilot study were easily accommodated during the course of the workshift. In most cases, workers arrived to work early to complete the pre-shift spirometry maneuver.

A large volume of data was collected in the pilot study, and the analysis of these data is on-going. Overall, these data show a wide range of exposures for career pig barn workers who participated in the pilot study. This was evident not only for a particular career pig barn worker over the course of their individual workshift, but also among different workers engaged in different work tasks, in different areas of the barn, and across different barns. Our preliminary data suggest that there may be grounds for concern about overall exposures (average exposures) and differing exposures (peak exposures) among career pig barn workers.

▪ Summary and Conclusions

Results from the pilot study demonstrated that researchers can access large pig barns in Alberta by following stringent biosecurity protocols and equipment disinfection procedures. In addition, extensive exposure and respiratory health information can be collected, with minimal disruptions to the daily routines of career pig barn workers.

These data showed that there are contaminants present in the pig barn environment in levels that may be problematic to the health of pig barn workers. In addition, different worker specialties and the unique work activities they engage in appear to influence their exposures to contaminants in the pig barn environment.

Other than in the pilot study, direct and continuous worker exposures have never been measured in a population of pig barn workers. This information is critical for developing informed strategies to ensure healthy working conditions. Additional knowledge of the range and extremes of contaminant exposures to respirable and inhalable dust, gases, and endotoxins is required. Additional information will enable us to recommend changes to work practices, barn management, design of facilities, and worker education.

We can ensure the sustainability of the pork industry in Alberta, by providing a healthy working environment for our highly trained and highly skilled workforce.

▪ Acknowledgements

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