

# Assessing daily exposure risk of pig barn workers to airborne contaminants



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Extended exposure of pig barn workers to airborne contaminants, particularly dust and gases (ammonia and hydrogen sulphide) is primarily associated with increased risk of developing respiratory symptoms and other health problems (Senthilselvan et al., 2007; Dosman et al., 2004). Various researchers have comprehensively investigated the work environment in pig barns and the associated effects on the health of barn workers. However, most of these studies focused on documenting the health symptoms and rarely involved characterization of occupational exposure environments in intensive livestock operation. Hence, to protect the health and safety of barn workers, there is a need to gain more understanding of the work environment in barns and the associated worker exposure risks.

The goals of this study were to assess the occupational exposure risk of barn workers to dust and gases while performing their assigned daily tasks in the barn, and to identify specific activities in the barn that pose high occupational exposure risk to workers.

This study was conducted in swine grow-finish rooms at the PSCI barn. The rooms included typical types of production rooms with different floor types (partially and fully-slatted floor), pen sizes (from 5-10 animals per pen), and room sizes (from 72-144 animals per room). A total of 18 monitoring days spanning winter and summer months over a one-year period were conducted to account for variations in seasonal conditions and to ensure a scientifically-valid evaluation



**Figure 1. Gas monitors and respirable dust sampling gear worn by the worker while performing specific tasks during personal sampling.**

of the collected data. Every monitoring day, the occupational exposure of a barn worker to respirable dust, ammonia ( $\text{NH}_3$ ) and hydrogen sulphide ( $\text{H}_2\text{S}$ ) was assessed by outfitting the barn worker with personal dust samplers and gas monitors over the course of the work shift (Figure 1). A regular working day of the barn worker involved carrying out various combinations of different tasks in the grow-finish rooms which may have included daily health check, feeding, pen floor scraping, pressure washing of rooms, loading out market pigs, weighing, among others. The worker was instructed to make sure that the personal monitoring equipment was continuously running while performing the regular assigned tasks, and to record in a logbook the time, location and the corresponding tasks performed while wearing the personal monitoring equipment.

The results shown in Table 1 indicated that the time-weighted average (TWA) exposure levels for all the monitored parameters were below their respective exposure limits. The barn worker had

a combined average respirable dust exposure of  $0.98 \text{ mg/m}^3$ , with the mean values ranging from  $0.42$  to  $2.50 \text{ mg/m}^3$ . Although the average respirable dust exposure levels were below the  $3.0 \text{ mg/m}^3$  threshold limit set by the American Conference of Governmental Industrial Hygienists (ACGIH), it is important to consider that respirable dust levels exceeding  $0.23 \text{ mg/m}^3$  were found to be associated with higher health risks in swine confinement workers (Donham, 1995).

The average  $\text{NH}_3$  exposure for the barn worker was found to be  $11.1 \text{ ppm}$  and ranged from  $1.3$  to  $21.4 \text{ ppm}$ . On the other hand, mean  $\text{H}_2\text{S}$  exposure for the barn worker was about  $1.3 \text{ ppm}$  and ranged from  $0$  to  $11.4 \text{ ppm}$ . Further examination of the real-time data showed certain peaks were recorded for both gases during certain periods while the worker was performing daily assigned barn tasks. Notably, a number of these peaks exceeded the corresponding short-term exposure limits (STEL) and TWA for these gases. For ammonia, 11 out of 18 monitoring days had

**Table 1. Occupational exposure of barn worker to respirable dust, gases and noise and their corresponding exposure limits.**

	Respirable dust, mg/m <sup>3</sup>	Ammonia, ppm	Hydrogen sulphide, ppm
Mean	0.98	11.1	1.3
SD	0.54	6.2	2.8
Range	0.42 - 2.50	1.3 - 21.4	0.0 - 11.4
Exposure limit	3 (TWA) <sup>1</sup>	25 (TWA); 35 (STEL) <sup>1,2</sup>	10 (TWA); 15 (STEL); 100 (IDLH) <sup>2</sup>

<sup>1</sup>ACGIH (American Conference of Governmental Industrial Hygienists)

<sup>2</sup>NIOSH (National Institute for Occupational Safety and Health)

TWA – Time Weighted average

STEL – Short Term Exposure limit

IDLH – Immediate Danger to Life or Health

exposure values higher than the exposure limit of 25 ppm NH<sub>3</sub>. These values were observed during feeding and weighing pigs as well as draining manure pits inside the room. High levels of H<sub>2</sub>S (as high as 202 ppm) were also recorded when performing manure handling activities particularly draining manure pits in the room.

After benchmarking the occupational exposure to airborne contaminants, five specific tasks that posed greater exposure risk to workers in swine barns were identified. These included weighing, feeding, marking, and loading pigs for market, as


well as draining manure pits inside the room. A task-based assessment of potential occupational exposure risk for each of the identified specific tasks was done over another year and results are shown in Figure 2.

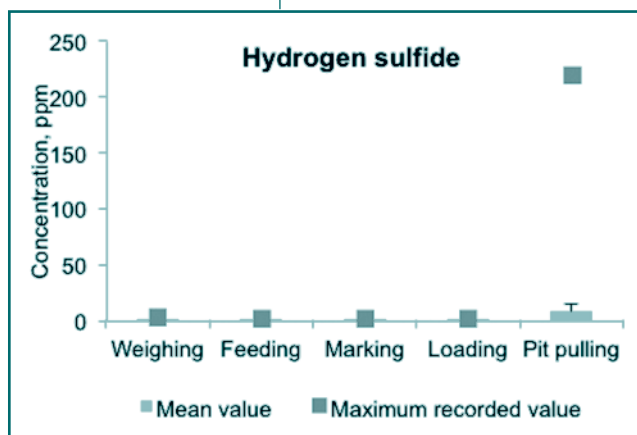
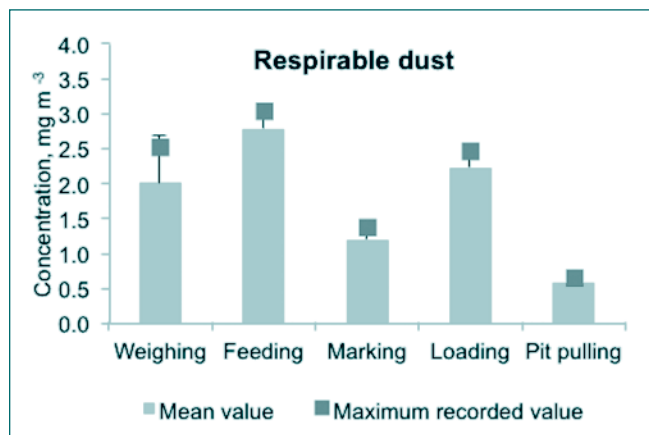
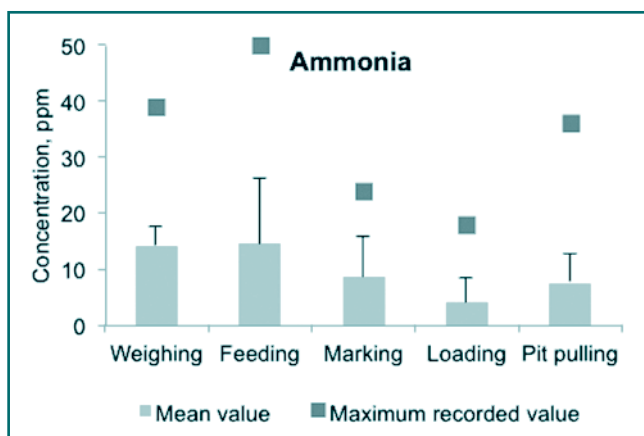
On average, all five tasks yielded NH<sub>3</sub> levels below the 25 ppm TWA exposure limit (Figure 2a). However, exposure to NH<sub>3</sub> levels exceeded the 35 ppm STEL at certain times while feeding, weighing pigs, and draining manure pits. Feeding pigs recorded a maximum NH<sub>3</sub> concentration of 50 ppm while weighing pigs and draining pits had peak NH<sub>3</sub> levels of 39 ppm and 36 ppm, respectively. Similarly, the average H<sub>2</sub>S exposure for all five tasks was found to be below the 10 ppm (TWA) and 15 ppm (STEL) threshold limit values (Figure 2b). Levels of H<sub>2</sub>S when draining manure pits were significantly higher (p<0.05) than the levels recorded when performing the other four tasks. This can be attributed to several

observed spikes in H<sub>2</sub>S levels while the worker was draining manure pits inside the room; these peaks (maximum of 220 ppm) exceeded the 100 ppm mark which is considered immediately dangerous to life or health (IDLH) according to the NIOSH guidelines. During these instances, the worker's H<sub>2</sub>S gas monitor emitted an alarm, which compelled the worker to immediately leave the area according to established safety protocol.

Feeding pigs resulted in the highest respirable dust exposure among the five tasks (Figure 2c), with a maximum recorded value of 3.04 mg/m<sup>3</sup>. The other selected tasks had levels below the 3.0 mg/m<sup>3</sup> threshold limit value established by ACGIH for airborne respirable particulates in the workplace. On average, respirable dust levels during feeding was significantly higher (p<0.05) than the levels during weighing and marking pigs as well as during manure pit clearing in the room. This can be attributed to the way feeding was done in this study which involved filling feed carts from the bin and distributing them into individual feeders inside the room.

### The Bottom Line

The occupational exposure of barn workers to respirable dust, ammonia and hydrogen sulphide while performing their assigned daily tasks in the barn was generally below the respective time-weighted average (TWA) exposure limits for each parameter (3 mg/m<sup>3</sup> for respirable dust, 25 ppm for NH<sub>3</sub> and 10 ppm for H<sub>2</sub>S). The variation in the time-weighted average of the airborne contaminants was dependent on the tasks the workers performed during any specific workday. Activities like feeding, weighing pigs, and draining manure pits, have a higher likelihood to result in exposures that exceed the 15-min threshold limit value and thus, pose greater occupational exposure risk to barn workers. 



**Figure 2. Exposure levels of barn worker to ammonia (a), hydrogen sulfide (b), and respirable dust (c) for each of the monitored tasks. Dashed horizontal line represents the time-weighted average (TWA) exposure limit for each hazard.**