Exposure of swine farm workers to dust during different working tasks

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Abstract

The aim of this study was to investigate the level of workers exposure during four different working tasks: (1) post natal piglet husbandry practices, (2) weaning, (3) post-weaning piglet feeding and (4) fattening pigs sorting. Those four tasks have been previously identified as the most dangerous one in term of dust exposure combined with a high level of efforts. The study was achieved on 10 pig farms located in Brittany. Thirty workers were visited during two seasons (summer and winter). Results presented in this paper concerned only the summer period. Before starting measurement, a first visit was organized individually with each worker and questions were asked about his current state of health but also on his past activity and his feeling about the risk related to his job. Before and after a work shift, they underwent lung function testing with a held spirometer. During work, they wore personal air sampling equipment (CIP10, Tecora) for the measure of inhaled particles. During the same period, measurements were achieved on the ambience for the determination of PM10, PM2.5 and TSP concentrations (Grimm, Intertek) but also ammonia, carbon dioxide, hydrogen sulfide concentrations (Drager tubes) and temperature inside each room (Konrad). Following the two collection periods, data were analyzed in relation with several technical parameters: size of the farm, labor specialization, season, tasks, feeding systems but also health status of farmers and the time spent working with swine

Keywords: pig, building, ammonia, PM_{10}, $PM_{2.5}$.

1. Introduction

In France, as in many countries in Europe, the development of intensive livestock production has been associated with increased stocking density and herd size. This has been accompanied by a rise of airborne pollutants in the ambience of plants leading to higher exposures for workers. In agriculture and probably, more specifically in pig plants, air quality appears now as a real concern for workers whether they are employees or employers. Previous studies have illustrated the impact of air quality and especially dust exposure on respiratory disorders in farm workers (Kogevinas et al., 1997; Senthilselvan et al., 1997). The purpose of our project is to assess French farmer's exposure level to dust and ammonia in pig buildings during four different working tasks which have been previously identified with the highest risk exposure combined with a high level of effort. The global project, led by the Brittany Chamber of Agriculture, has a total of twenty farms and sixty workers who will be followed during two consecutive periods (summer and winter). Results presented in this paper concerns only ten farms and thirty workers followed during the summer period. Data obtained for the winter period are being processed and analyzed.

2. Materials and Methods

Measurements and recordings were achieved on ten farms located in Brittany. The average size of these farms was 364 ± 176 present sows characterized in two categories: (1) pig farms under 300 sows with an average of 202± 41 sows and (2) pig farms over 300 sows with an average of 471±143 sows. The choice of those categories led us to have non-specialized workers in the first one and very specialized workers with the second one.

Concentrations in the ambient air and exposure of workers were measured and recorded during four working tasks.

- The first task is dedicated to post natal piglet husbandry practices immediately after the end of farrowing and less to 48 hours after. In order to increase piglets survival and for the welfare of the sow, various interventions were provided on piglets. Among the most common interventions: tail docking, teeth clipping or grinding, castration and antibiotic injection. This task was considered a risky one because handling of the animals can trigger the suspension of particles in the ambient air and represents a great physical effort for workers.

- The second task is dedicated to the weaning of piglets. Between three and four weeks after birth, piglets are weaned from the sow and moved to others rooms. The high level of animal activity generated by the weaning stress of piglets lead to high level of suspended particles in the ambient air. As for the first task, the second one requires a lot of energy dispended by farmers.

- The third task is dedicated to post-weaning piglets and more especially to the feed distribution. During the first days after weaning, farmers distributes meal feed to piglets. Most of the times, this distribution is a manual one. It is an opportunity for farmers to control piglet's behavior. This third task requires less energy than the previous one but the risk is linked to feed presentation.

- The fourth task is dedicated to fattening pigs and especially to pig sorting. Thirteen to fifteen weeks after weaning, farmers sort heaviest pigs for slaughter. The weight of heaviest pigs is around 110 – 130 kg and farmers must isolate heaviest pigs to move them to the loading bay and keep the lightest ones inside the room. As for the second task, animal activity can generate a high concentration of suspended particles and it requires a lot of energy for farmers.

Information on working tasks and stable characteristics were collected using reported activity diary and walk-through surveys performed in conjunction with the measurements.

On the ambient air, dust concentrations (TSP, PM_{10}, $PM_{2.5}$ and PM_1) were performed by one GRIMM1.100 spectrometer (Intertek) (one minute sampling interval) close to the area of workers. Measurements were achieved during the whole presence of workers in the room. At the same time, NH_3, CO_2 and H_2S concentrations inside the room were measured by using direct-reading diffusion tubes (Dräger). Three measures were performed during each task (beginning, middle and end of the duration). Thermo-hygrometer (Conrad DL-121 TH) were placed in the room and outside the building throughout the task. Ventilation data were collected at the beginning and at the end of each task.

For the personal air sampling, concentrations of $PM_{2.5}$ were measured during the task. Workers wore an air sampling equipment (CIP 10) near their breathing zone.

Photo 1: On the left: Personal air sampler during the teeth clipping – On the right: dust measurements with Grimm spectrometer

Characteristics of all rooms concerned by each task were recorded: size, number of animals per category, ventilation system: air intake and outlet, number and size of fans, type of floor, slurry management, air treatment. During the task, the activity of the worker was described and timed. It offered the opportunity to make a direct link between the activity of the worker – especially when it was necessary to move frequently to others rooms – and the potential evolution of dust concentrations.

3. Results and Discussion

The average duration task recorded during this first measurement campaign was 49±38 minutes. The minimum value was logically obtained for the task 3 (manual distribution of feed for post-weaning piglets) with 13±4 minutes and the maximum value for the task 1 (post natal piglet husbandry practices) with 83±42 minutes.

The outside temperature during this first campaign was 21.8±2.3°C. This value was quiet low for a summer period but main measurements were achieved early in the morning, especially for the task 2 (weaning of piglets). The average ambient temperature was 25.9±1.4°C with differences between tasks according to the management of ventilation in each physiological stages. Ambient temperatures recorded with sensors are consistent with values given by the ventilation

system (Table 1).

Table 1. Average ambient temperatures (in °C) per task compared to ambient temperatures given by the ventilation system.

Task	Average ambient temperature measured (°C)	Average ambient temperature given by the ventilation system (°C)	Average outside temperature (°C)
Task 1 (post natal piglet husbandry practices)	26.3±1.2	27.0±1.3	23.4±2.1
Task 2 (weaning of piglets)	24.7±1.3	23.6±1.2	20.3±1.8
Task 3 (feed distribution)	27.3±0.9	27.5±0.5	22.1±2.3
Task 4 (pig sorting)	26.8±0.9	27.0±1.3	20.9±1.7

Average concentrations of ammonia, carbon dioxide and hydrogen sulfide measured per task are given in the following table (Table 2). Average NH_3 concentrations were very low with high variation among tasks. The highest value was measured for the last task (number 4 – pig sorting) explaining by the weight of pigs and the storage of slurry in the pit. Those values are lower than values published in the literature (Guingand, 2003 – Mc Donnell et al., 2008). This difference can be explained by the period of measurements which was directly linked to the duration of the task.

Table 2. Gaseous concentrations per task

Task	NH_3 concentrations (ppm)	CO_2 concentrations (%)	H_2S concentrations (ppm)
Task 1 (postnatal piglet husbandry practices)	2.6±1.8	0.11±0.10	0
Task 2 (weaning of piglets)	4.0±1.3	0.10±0.10	0
Task 3 (feed distribution)	3.8±3.0	0.13±0.09	0
Task 4 (pig sorting)	8.8±5.6	0.12±0.08	0

In all cases, ammonia concentrations were lower than the occupational exposure limit value imposed by the French legislation about working conditions. In fact, the occupational exposure limit value for 8hr-operation is 10 ppm and 20 ppm for the maximal exposure limit value for a duration of 15 minutes (Inrs, 2012).

In our study, Total Suspended Particles (TSP) concentrations ranged between 1.7 and 240 mg/m^3 in relation with the type of task (Table 3). Except for the two last task, those values were consistent with literature already published on dust concentrations in the ambiance of piggeries (Donham, 1986 – Michiels et al., 2015). The difference observed especially for tasks 3 and 4 was probably due to the aim of the study. In previous references, measurements were achieved to assess dust concentrations in the ambiance related to specific equipment or feed strategy. In most cases, animal activity was normal and no human action - expect the supervision of animals - took place during the measurement period. In our study, measurements were limited to the duration period of workers, increasing drastically dust concentrations in the ambiance.

Table 3. Dust concentrations per task

Task	Total Suspended Particles (mg/m^3)	Ambient concentration			Personal air sampling (CIP10) $PM_{2.5}$ (mg/m^3)
		PM_{10} (mg/m^3)	$PM_{2.5}$ (mg/m^3)	PM_1 (mg/m^3)	
Task 1 (postnatal piglet husbandry practices)	1.70±1.00	0.90±0.60	0.09±0.07	0.03±0.03	0.5±0.2
Task 2 (weaning of piglets)	4.10±1.30	2.60±0.90	0.18±0.09	0.02±0.01	0.6±0.1
Task 3 (feed distribution)	240.00±42.00	2.10±2.50	0.45±0.72	0.04±0.06	0.7±0.2
Task 4 (pig sorting)	71.00±12.00	4.10±3.30	0.29±0.18	0.03±0.02	0.4±0.1

The highest level of TSP was recorded during the distribution of feed for piglets and the lowest during post natal

piglet husbandry practices. Even if TSP was the highest during feed distribution and pig sorting, concentrations of PM_{10} and $PM_{2.5}$ were in the same range of values that those obtained during the weaning of piglets. The first task, postnatal piglet husbandry practices, showed the lowest level of dust for all particles fractions.

Dust measurements in breathing zone obtained with CIP10-measurements showed low concentrations of $PM_{2.5}$ which were more or less close to measurements obtained on the ambient air. A lot of data obtained with the CIP10 equipped with the $PM_{2.5}$ filter were unusable. Change in the filter type was considered for the next campaign.

The influence of some technical parameters related to the building characteristics or practices were analyzed on dust concentration. Dust concentrations were lower in the ambiance of pressured rooms compared to depression system (1.9 vs 3.6 mg/m3 for $PM_{2.5}$ respectively for pressured and depressed rooms). In the same way, rooms with scraping system showed lower concentrations of dust than traditional rooms with slurry storage in the pit (2.3 vs 1.1 mg/m3 for $PM_{2.5}$ respectively for rooms with scraper and slurry storage in the pit).

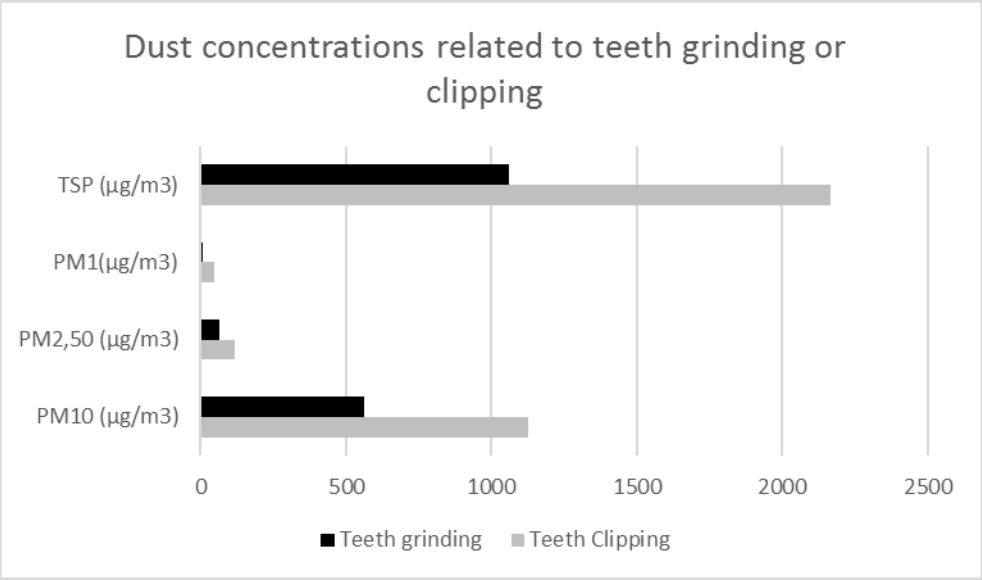

Figure 1: Effect of teeth grinding or clipping on dust concentrations

The impact of some practices was also identified. Dust concentrations appeared to be lower during teeth grinding compared to clipping (Figure 1). Teeth clipping probably produced large particles which settled very rapidly and were not included in the TSP fraction. No statistical effect was identified because of the small number of data. Statistical analysis will be carried on all data acquired at the end of the project.

4. Conclusions

In our study, the highest concentrations of particles, all fractions considered, was obtained during the feed distribution and the pig sorting. The highest concentration of ammonia was also measured for this last task. High levels of exposure were combined with an intense physical activity achieved by worker. It appeared as the most risky task for workers. The type of activities played a dominant role on the exposure variability. Working tasks with intense animal activity like pig sorting combined or not with handling of feed materials like feed distribution, increased exposure concentrations.

At the opposite, postnatal piglet husbandry practices generated the lowest level of dust and ammonia concentrations, showing a lower level of risk for worker. Nevertheless, it was the longest task in term of duration. The combination between exposure levels, physical activity and duration will be analyzed in relation with worker physical performances recorded at the beginning and at the end of each task in the second step of this project.

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