Measurement of Dust Exposure During Straw Distribution in Piggery

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Abstract

Straw handling in pig barn is one of the most troublesomely manual tasks due to the dust exposure. This paper presents the measurement results on dust exposure for straw distribution in piggery. The work included the measurements of working time requirement and airborne dust exposure at pig barns in Sweden. The measurements were carried out by a personal particulate monitor mounted on farmers during working on distribution of various bedding materials at different pig barns. Endotoxins and microorganisms contained in the dust were analyzed from the personal sampling in the breathing zone. The working tasks that were investigated at daily manual straw handling were: a) mucking out by scraper in pigpen, b) loading straw into handcart in storeroom, c) moving straw between the storeroom and pigpen, d) distributing straw and littering down in pig pen, etc. The results show that the concentrations of endotoxins in the pig farms investigated exceed an exposure risk limit for inflammation of respiratory tract. An extremely high content (>5700 ng/m^3) of endotoxin in airborne dusts was measured with a farmer when he was manually littering oats straw in one of the pig farms, and an automatic dry feeding was in process. The results of microbiologic analysis also show that airborne dusts contain an amount of bacterium and mould fungus. In order to reduce the health risk for the farmers, some approaches on improvement for such working environments were discussed.

Keywords: airborne dust, endotoxin, farmer, healthrisk, working environment

Introduction

The swine building is a dusty working environment, and the daily straw distribution is one of the most hazardous working tasks for the farmers. Swine confinement workers suffer a higher prevalence of respiratory symptoms, such as cough, phlegm, chest tightness, and wheezing, rather than the rest of the population. (Cormier, et al., 1990; Larsson, 2001; Larsson, et al., 2002; Banhazi, et al., 2008; Sundblad, et al., 2009). This is because the organic dust in swine confinements contains a lot of microorganisms, bacteria and bacterial products, such as endotoxins. Inhalation of organic dust in swine house can induce acute airway inflammation and increase bronchial responsiveness, resulting in a rise to diseases of the respiratory tracts and lungs. (Rylander, 1986; Larsson 1990; Malmberg m.fl., 1987; Kirkhorn & Garry, 2000; Viet m.fl., 2001; Müller-Suur, 2002; Spurzem m.fl., 2002). Endotoxin is believed to be a responsible agent for the majority of acute dust exposure related to the respirator problems (Clark, et al., 1983; Shiefer & Hancock, 1984; Creasia et al., 1987; Donham, et al., 1989; Creasia et al., 1990; Pitt, 1994; Douwes et al., 1997; Wang, 1997; Skaug et al., 2000; Larsson, 2001).

The Provisions of the Swedish Work Environment Authority on Occupational Exposure Limit values (OEL, AFS 2005:17) give a level limit value for total organic dust content (5 mg/m^3 in air during one working day). This limit value refers to the maximum acceptable concentration of dust from organic substances, and it does not allow for specially hazardous components of biological origin. Components of the biological origin include, for instance, endotoxins, bacteria, mite excrement and fungal spores, as well as severely allergenic substances like particles from animal hair, epithelium and bacterial spores. The special limit values for such hazardous components are still lacking. The hygienic quality of straw has an important bearing on the work environment, especially mouldy straw that encloses a lot of endotoxins and microorganisms (Gustafsson and von Wachenfelt, 1993; Larsson, K. and Ihrsén S., 1996).

As a dose response, the dust concentration and the exposure duration both are important factors. A higher concentration and longer exposure duration to the dusts increase the health risk of likelihood. The duration of the OEL values for total organic dust content in air at 5 mg/m^3 is for exposure during one whole working day of eight hours (AFS 2005:17). There is also an occupation exposure limit value for exposure during a reference period of 15 minutes (short-term value, AFS 2005:17). The short-term values are used for swift-acting or otherwise especially dangerous substances. In fact, the farmers usually are exposed to much higher concentration of organic dust during daily ditrubution of strew for a shorter duration in swin house. However, the information regarding whether there is a health risk on the respiratory system for this kind of daily work on strew handling is still missing.

The aim of this paper was to investigate the exposure to organic airborne dust when farmer handle strew in swine barns.

Methods

The work included the measurements of working time requirement and airborne dust exposure at ten large pig barns in Sweden. Exposure to dusts was investigated by measuring the concentration of airborne dust as well as by analyzing endotoxins and microorganisms sampled from the personal sampling in the breathing zone (Figure 1). To obtain a representative overview of real time exposure to organic dust, the measurements were performed with each farmer during a really working shift in a pig barn when he/she operated the tasks.

Figure 1. Instrument used for the personal sampling (a portable air pump that was connected with two sampling filters and the DataRAM).

The real-time concentration of airborne dust was monitored with personal sampling by an instrument named personal pDataRAM (Thermo Electron Corporation, 2005). A model pDR-1000AN of the pDataRAM performed the measurement fraction of the airborne dust (particle size range: 0,1 to 10 µm; concentration range: 0,001 to 400 mg/m^3). The data were collected in every 5th second, and the stored data were downloaded to a personal computer for the data management and analysis. The results related to air volume were expressed as milligrams per cubic meter (mg/m^3) for the concentration of airborne dust.

The contents of endotoxins and microorganisms in the airborne dust sampled during the operation were verified by chemical analyses. A portable air pump that was connected with two sampling filters was used for the personal sampling in the breathing zone (Figure 1). After each measurement, the sampled filters were immediately left to the laboratory of Pegasus Lab for the analyses. The results related to air volume were expressed as nanograms per cubic meter (ng/m^3) for the endotoxins and that given as spores/m^3 for the microorganisms.

The working tasks investigated at manual straw hantering were: mucking out by scraper in pigpen, loading straw into handcart in storeroom, moving straw between the storeroom and pigpen, distributing straw and littering in pigpen, etc. (Figure 2). In each investigation, the performance of the tasks and the working duration were observed and recorded. In addition, the type of straw used, and climate (air temperature and relative huminitity) were recorded during the measurement.

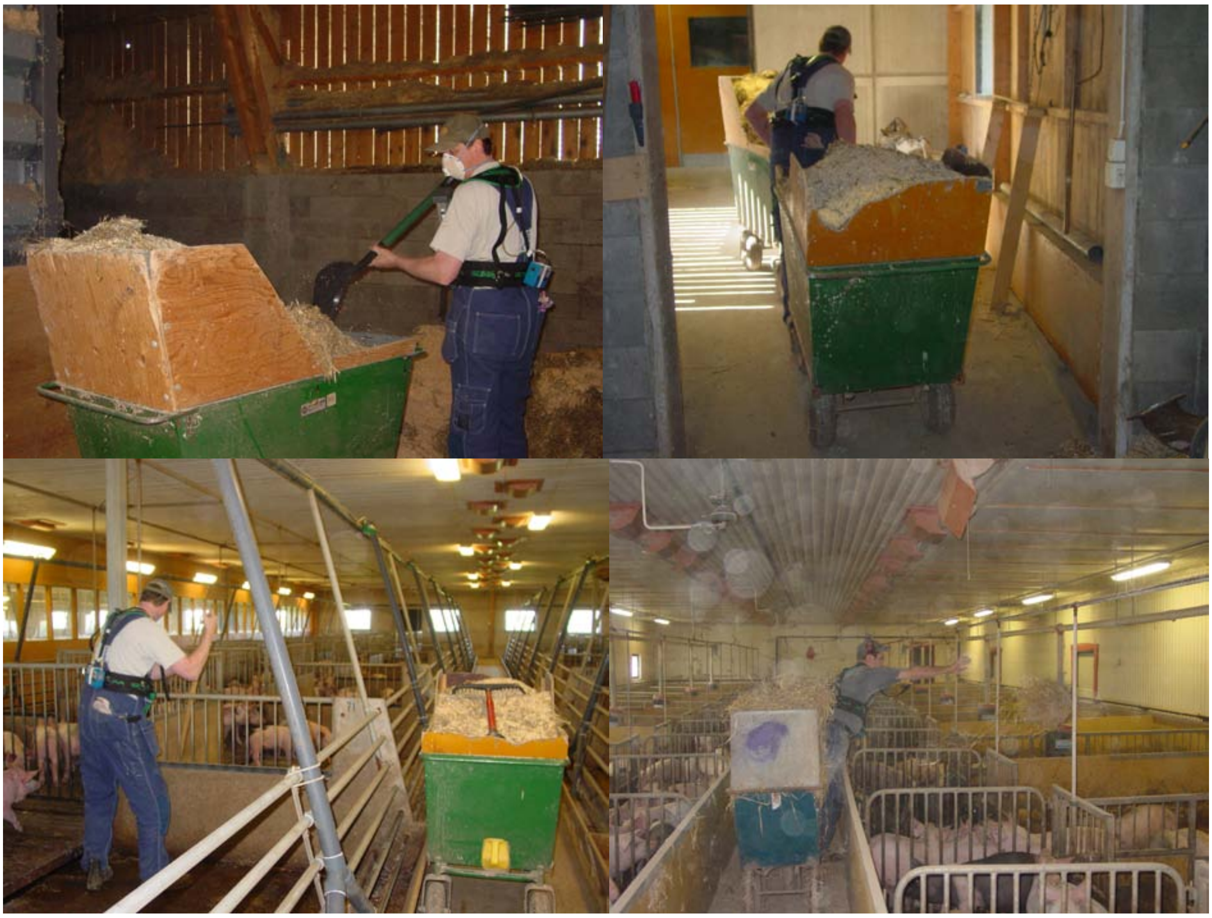

Figure 2. The working tasks investigated.

Results and discussion

The general information about the swine farms studied is described in Table 1. The duration of each measurement varies much among the farms due to differnt sizes of the swine barns.

Table 1. General information for the measurement conditions.

Study nr	Straw sort	Air temperature (ºC)		Relative humidity (%)		Measuring duration (minut)	Barns' size for number of pig
		Indoor	Outdoor	Indoor	Outdoor		
1	Wheat straw & Shavings	18-20	17,2	63-65	54,8	130[1)]	9*360
2	Wheat straw	19-21	16	57-58	62	129	2*(240+370)
3	Wheat straw	18-20	8	61-63	-	47	4*120
4	Wheat straw & Shavings	21-26	23	70-77	68	31[2)]	5*300
5	Wheat straw & Shavings	26-28	-	68-70	-	56	2*400 1*360
6	Barley straw & Shavings	16-21	2	56-75	60	81	3*330
7	Wheat straw[3)]	15-17	7	82-89	96	40	2*140 2*210
8	Oats straw	19	15	56-57	44,4	32	240+280
9	Barley straw	13-15	12	50-70	41	57	9*300
10	Wheat straw	14-16	14	45-66	28	46	2*240+140

[1)]: A break for 44 minutes in the building was included; the real working duration was 86 minutes.

[2)]: Worked for only distribution and litter of straw without mucking out during measurement.

[3)]: The straws have been stored for 2-3 years.

Dust concentration

Figures 3 - 5 show the examples on the variations of dust concentration measured by the pDR-1000AN with three of the participators during operating the tasks under different working conditions as described above. Clearly, the dust concentration varied both at various activities and in different pig barns. The airborne dusty concentration was higher than the health risk for OEL value of 5 mg/m^3 when the farmers loaded streaw into the handcart and moved it to pigpens as well as distrabuted and littered down strews at two differnt swine farms (Figures 3 and 4).

In addition, Figure 3 shows that the airborne dust measured for mucking out was lower than that for distrabuting and littering strews operated by a famer in the same swine building.

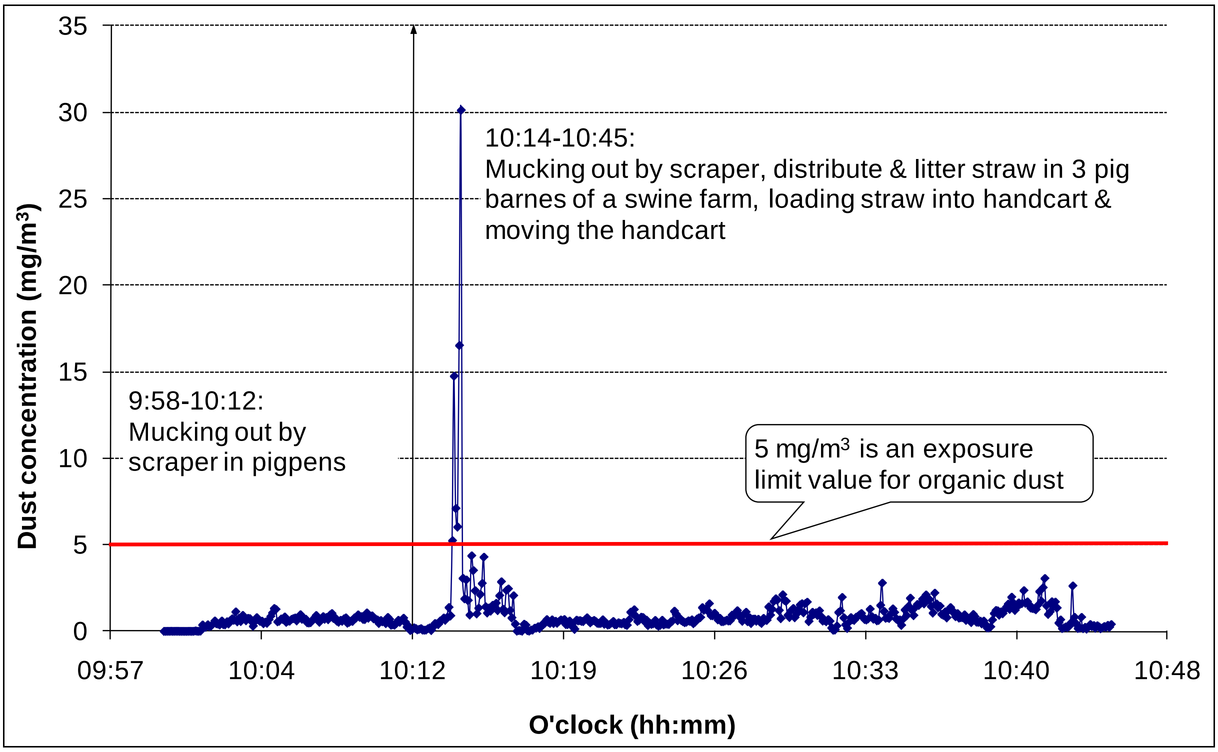

Figure 3. The dusty concentration versus working time measured with farmer by the pDR-1000AN.

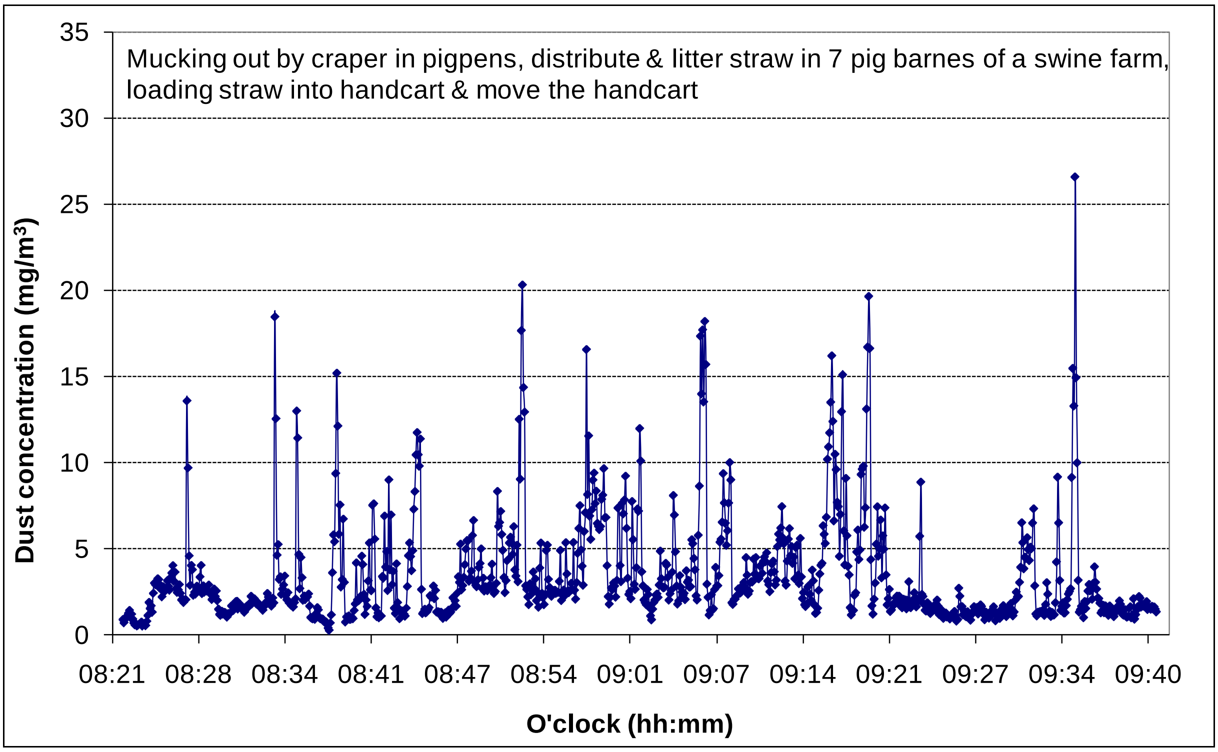

Figure 4. The dusty concentration versus working time measured with farmer by the pDR-1000AN.

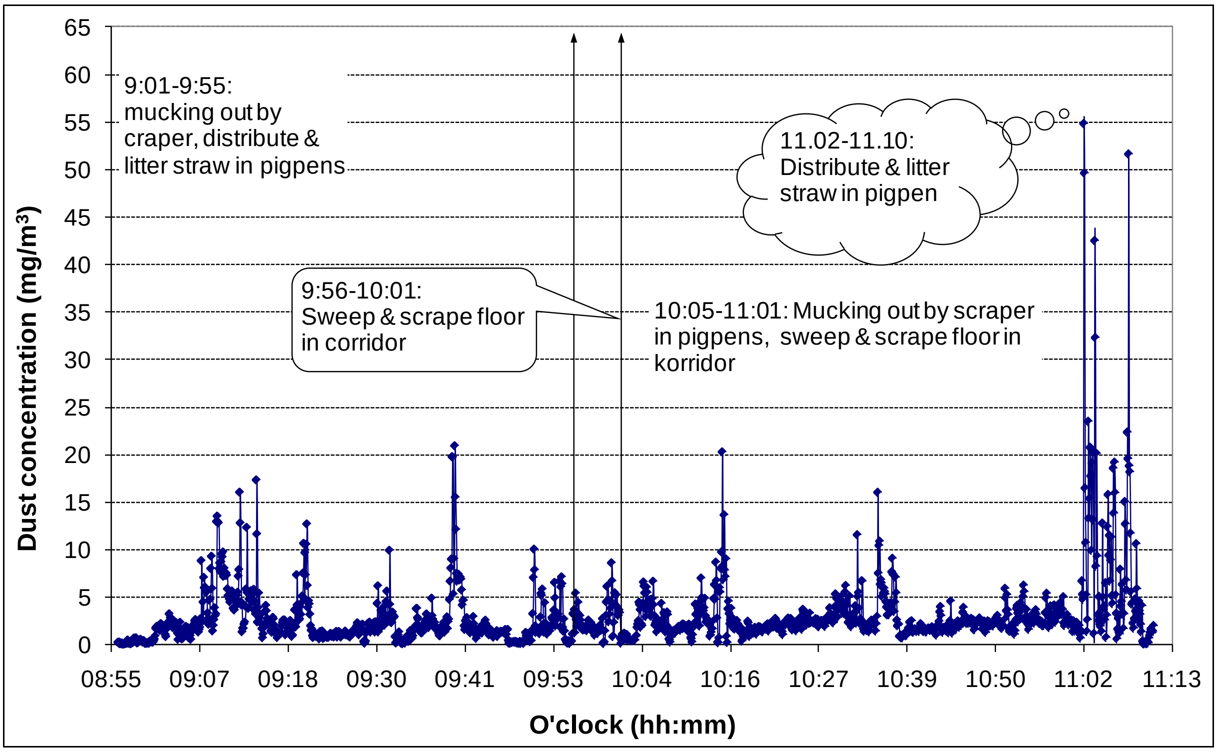

Figure 5. The dusty concentration versus working time during measured with farmer by the pDR-1000AN.

An extremely high concentration of airborne dust of 55 mg/m^3 was explored when distrabuting and littering strews in a swine building (Figure 5). Large quantities of organic dust were formed and released into air when chopped straw were distributed and littered in pigpens. In such a dusty working condition, the technical measures against the airborne dust concentration are thus needed. The farmers' exposure to such a harmful dust would be reduced via technical measures, for instance, introduction of an automatic equipment for straw distribution instead of daily manual straw handling in swine barns.

Endotoxin and microorganisms

Table 2 gives the results of concentration of endotoxins and microorganisms that were analyzed from the airborne dust with the personal samplings. Clearly, the all concentration values of the edotoxins exceed a risk level of 10 ng/m^3, which is a risk limit for inflammation of respiratory tract (Douwex, et al., 1997; Wesén 2009). According to Douwes, et al. (1997) and Wessén (2009), there was a risk for toxic pneumonia (fever reaction and irritation of respiratory tract) when a person was exposed to the endotoxin amount level at 200 ng/m^3 in air. It can be seen that eight of the ten values of endotoxin in the airborne dust measured with the farmers overstepped 218 ng/m^3. As known, organic dust in swine confinement buildings usually contains bacteria and endotoxins, as well as epithelium from the swine.

An extremely high content (>5700 ng/m3) of endotoxin in airborne dust was measured with a farmer when he was manually littering barley's straw in one of the pig farms. Noticed that during this measurement an automatic dry feeding was in proceed in this swine building. Large quantities of the organic dust could occur during the feeding, due to the dust generated both by dry feeding and by increased activity of the swine.

The analysis of microorganisms shown in Table 2 (Lager, 2009 and Wesén 2009) indicates that the airborne dust for the cases nr 3, 4, 6, 7, 8, 9 and 10 contained a large amount of bacteria (aureobasidium, streptomyces, trichoderma) and mould fungus (e.g. aspergillus spp, penicillium spp, jäst). It was observed that the quality of wheat straws used in the case nr 7 was not good as the straws have been stored for more that 2-3 years. The old straw could generate mould and toxic dust. The hygienic quailty of straws has a very important bearing on the airbrone dust. Handling of mouldy straw should be avoided as far ad possible. All bacteria and mould fungus belong to microorganisms in the airborne dust that are invisible to the naked eye, generating toxic dust in air. Also, the results show that the airborne dust contained a large amount of toxic producer (alternarium, eurotium, fusarium, trichoderma and wallemia), causing the high concentration of the endotoxin. Therefore, the technical and organisational measures to reduce the airborne concentration of these hazardous substances should be conducted.

If the technical measures cannot be taken or are insufficient, suitable personal protective equipment shall be used as a last resort. However, only three of the ten farmers who participated in the study used the respiratory protective device. The farmers should thus be informed of what kind of the risk exists when he/she exposed to organic dust, in which dusty condition the protective device must be used and how the risk could be reduced as well.

Table 2. Concentrations of total airbone endotoxin and microorganism in pig barns

Case nr	Endotoxin (ng/m^3)	Microorganism (spore /m^3)		Risk for respirator problem's organisms	Toxic producer
		Bacterium	Fungi		
1	***217,92****	1,6*10^6	2,7*10^5	Alternarium,	Aureobasidium, Streptomyces
2	***415,77***	6,1*10^6	1,5*10^6	Wallemia	Streptomyces
3	***492,98***	***1,5*10^7***	4,4*10^6	Trichoderma, Eurotium	***Streptomyces, Trichoderma***
4	75,46	***2,2*10^7***	4,0*10^5		***Streptomyces***
5	77,46	9,6*10^6	3,5*10^5	Fusarium	
6	***795,41***	***5,1*10^7***	5,8*10^6	Trichoderma	***Aureobasidium, Trichoderma***
7	***1314,52***	***1,4*10^8***	9,4*10^6		***Streptomyces***
8	***5769,74***	***4,3*10^7***	2,5*10^6	Fusarium	
9	***1238,39***	***3,1*10^7***	8*10^6		
10	***407,38***	***6,3*10^7***	2,1*10^6	Eurotium	Aspergillus niger, ***Streptomyces***

*: the contents of endotoxin and microorganisms as well as labels of the toxic producer shown by ***Italic boldface*** exceed the health risk limits.

It is recognized that farmers are often exposed to many potentially hazardous substances related to their work such as mineral and organic dust containing endotoxin, bacteria, allergens, fungi (e.g. straw dust, mouldy hay, animals), chemicals (e.g. fertilizers, pesticides, disinfectants), and gases (from animal manure pits, exhaust of machines) as well (AFS 2005:01; AFS 2008:17; Baekbo, 1990; JTI, 1990; Radon, et al., 2002; Rylander R., et al., 1989; Michel, et al., 1992).

The dust exposure is related to the exposure time when workers operate in a dusty environment. The reduction of the exposure duration in such a dusty working environment will thus have a direct effect on health. According to the Swedish regulation (AFS 2005:17), for one substance has different limit values, such as level limit value and short-term value. The reference period of the exposure should be eight hours for the level limit value (8-hours OEL). Additional investigation of dust exposure during working with different operations over one whole working day is therefore a necessity. For the short-term value, it has been defined as a recommended value consisting of a time-weighted average for exposure during a reference period of 15 minutes (STEL-15m). The short-term values are intended to protect workers during a short exposure to dangerous substances. These exposure limits cover risks from microorganisms such as viruses, bacteria, parasites, and fungi. Exposure to microorganisms is particularly relevant for farmers who work with swine in piggery. In Swedish regulation of AFS 2005:17, the STEL-15m value for organic dust in air has not yet been established. Further studies of exposure to the dust related to daily straw handling in swine barns for 15 minutes are thus essential to contribute the database on STEL-15m values for dangerous substances. This is because some substances have a STEL-15m value that should not be exceeded at any time to ensure protection against both acute effects, such as throat irritation, and chronic, long-term effects.

Conclusions

High concentrations of airborne dust occurred when the farmers operated tasks in swine barns, particularly for loading streaw into the handcart and transporting it to pigpens as well as distrabuting and littering down strews in pigpens.

All of the farmers investigated were exposed to high concentrations of endotoxins, which exceeded an exposure health risk level for inflammation of respiratory tract.

An extremely high concentration of endotoxin in airborne dusts was measured with a farmer when he was manually littering oats straw in pigpens together with the increased activity of swine while dry feeding was automatically in progress.

The airborne dust measured in most of the swine barns contained a large amount of bacteria and mould fungus. Preventively technical and organisational measures to reduce the airborne concentration of these hazardous substances should be conducted in the swine barns.

Further investigations of exposure to the airborne dusts related to daily work in swine barns for the reference period of both for 8 hours and for 15 minutes are essential.

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