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THE TOTAL NUMBER OF DUST PARTICLES AND THE PORTION OF THE RESPIRABLE DUST FRACTION IN THE AIR OF A SWINE FATTENING BUILDING

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In swine fattening units, where animals are densely confined, dust from the animals, their skin, hair, feces and urine and their feed, especially during agitation and emptying, can rise to harmful levels both for workers and pigs. Dust level is the highest in winter, although it increases whenever pigs are fed, handled, or moved. At least one third of dust particles are within the respirable size range and can affect lung tissues, large and small airways. Considering all problems that occur with dust in swine confinement buildings, the aim of the study was determination of the portion of respirable dust fraction in the total number of dust particles throughout the fattening period. The experiment was carried out on one pig farm near Belgrade in 1999 and 2000 during the winter months. The results obtained by the conimetric method point to the large amount of respirable dust particles (greater than 70%) in all dust samples taken from the air at all vertical levels above the floor (20, 50 and 170 cm) in the full fattening pig unit (180 pigs) .

Key words: dust, respirable fraction, swine fattening house

INTRODUCTION

According to Gustafsson (1999) dust in pig confinement buildings may create negative health effects on humans as well as on the animals. Inhalation of dust can give rise to diseases of the airways and lungs (acute toxic alveolitis, allergic alveolitis, asthma, chronic bronchial catarrh, coughs, nasal catarrh, nasal congestion, etc.)

Dust can contain inorganic material, such as particles of sand or organic material, such as pollen, fungal spores, fungal hyphae, mycotoxins, bacteria and endotoxins. Dust from livestock pens also includes, particles from skin, hair, feathers and excrement. According to the Swedish National Board of Occupational Safety and Health on Organic Dust in Agriculture (1994) the contents depend on where, when and how the dust is produced (season, geographical location and moisture content).

Factors affecting the generation and concentration of dust in pig houses are: feeding (Robertson, 1993), activity, number and weight of pigs (Gustafsson, 1994; Gustafsson, 1999; Pedersen, 1993; van't Klooster *et al.*, 1993), ventilation rate

(Gustafsson, 1994) and ventilation technique (van't Klooster *et al.*, 1993), temperature differences between the barn and outside air (Heber *et al.*, 1988) etc. The concentration of dust in swine buildings increases with the animals' activity and density. Dust levels are highest in winter in closed swine units. Tasks in which particularly high concentrations of dust occur include: the transfer of swine for slaughter between pens, selection for slaughter, weighing, bedding work and manual feeding (Swedish National Board of Occupational Safety and Health on Organic Dust in Agriculture, 1994).

Since dusts include both respirable (~10 μm) and larger inhalable (10-50 μm) particles, lung tissues, large airways and small airways may all be affected. One third of dust particles are within the respirable size range. In a review of intensive animal environments, Pickrell (1990) concluded that swine building environments contained the highest quantities of particles and bacteria (relative to other animal environments) capable of being deposited in the deep lung. These particles consist of feed dust, skin flakes, and animal feces, and are specified by Carpenter (1986) as being less than 5 μm (capable of penetrating the lungs), 5-10 μm (reaching the lower airways), and greater than 10 μm (being deposited in the nasal passage and throat) in size. Particles smaller than 5 μm exceeded 95 percent of total materials using an optical instrument measure and 75 percent using an Andersen sampler in a finisher shed. Therefore most of these particles are capable of invading a human host via the respiratory tract. The settling rate of dust under gravity is described by Carr (1994), who points out that particles of less than 5 μm settle slowly and need only slight air movement to stay aloft. The constant turbulent conditions surrounding intensive animal production will keep these particles suspended while larger particles settle out.

Dust concentration in the air can be reduced by fogging, spraying or sprinkling not only oil mixtures but also pure water (Zhang, 1999; Lemay *et al.*, 1999; Osman *et al.*, 1999; Nonnenman *et al.*, 1999).

The portion of respirable dust particles capable of penetrating lung tissues in a closed swine unit has been measured in this study.

MATERIALS AND METHODS

The total number and the number of nonrespirable dust particles (larger than 5 μm) in the indoor air of a fattening pig house on a farm near Belgrade were measured. The capacity of the fattening unit was 180 pigs distributed within 18 boxes (10 pigs per box). The investigation was carried out in 1999 and 2000 during the winter months. The total number of dust particles and number of particles of the nonrespirable fraction were counted with the optical particle counter - conimeter (Carl Zeiss Jena) by the standard conimetric method (Radenkovic, 1998). The instrument was used as a sampler of the air (1 cm^3), and for counting and determination of the size and the shape of particles. The number of counted particles in 1 cm^3 of the air sample was multiplied by 10^6 to calculate the number of dust particles in 1 m^3 of the indoor air. The total number and the number of dust particles larger than 5 μm ($n_t \times 10^6/m^3$ - the total number of dust particles; $n \times 10^6/m^3$ - the number of dust particles larger than 5 m) were measured at different vertical levels above the floor (20 cm, 50 cm and 170 cm) and in different fattening periods (one day before the start of fattening in an empty house, the first day of the fattening, at the end of the first, second, third and fourth months of the fattening period and one day after the finish in an empty house). For each vertical level above the floor and each fattening phase there were. 10 samples of the air. Statistical analysis of data was made by the computer statistical programme Stat Soft.

RESULTS

Table 1. shows the total number of dust particles, number of dust particles larger than 5 μm and the portion of respirable dust particles (<5 μm) in the air of the fattening pig house. The total number of dust particles increased with length of the fattening period. Thus, the smallest total number of dust particles was found one day before occupation at the vertical level of 170 cm above the floor (7,60 ±1,65 x $10^6/m^3$) in an empty fattening unit. The largest total number of dust particles was observed on the last day of the fattening at the level of 20 cm above the floor (137,90±20,99 x $10^6/m^3$). One day after the fattening had finished the total number of dust particles had decreased rapidly, so in the empty pig house it ranged from 16,90±5,61 x $10^6/m^3$ (170 cm) to 80,60±7,99 x $10^6/m^3$ (20 cm). Also the total number of dust particles decreased as the vertical level of the place of dust sampling increased. At the level of 170 cm above the floor the smallest total number of dust particles was found at times. As the total number of dust particles increased the portion of respirable dust particles (< 5 μm) increased, too. Thus in the dust samples taken one day before occupation in an empty pig fattening unit the portion of respirable dust particles ranged from 32,22% to 61,46%. From the first day to the last day of fattening, the portion of respirable dust particles varied from 70,52% (50 cm above the floor) to 92,54% (20 cm above the floor), respectively. One day after the fattening had finished the portion of respirable dust fraction decreased slowly and ranged from 75,74% (170 cm) to 90,24% (20 cm).

Table 1. Total number and the portion of respirable dust particles

Time of dust sampling	Vertical level above the floor	Total number of dust particles		Number of dust particles larger than 5 μm		Portion of respirable dust particles (≤ 5 μm)
	cm	n_t x 10^6/m^3	%	n x 10^6/m^3	%	%
A day before occupation	20	9,60 ± 1,51	100	3,70 ± 0,95	38,54	61,46
	50	8,40 ±1,90	100	4,10 ± 1,07	48,80	51,20
	170	7,60 ± 1,65	100	5,00 ± 1,19	65,78	32,22
The first day of fattening	20	37,80 ± 3,46	100	6,00 ± 1,73	15,87	84,13
	50	32,90 ± 3,54	100	9,70 ± 1,84	29,48	70,52
	170	26,10 ± 5,26	100	7,60 ± 2,01	29,11	70,89
The second month of fattening	20	100,30 ±4,14	100	9,40 ± 2,17	9,37	90,60
	50	62,00 ±4,27	100	9,30 ± 2,03	15,00	85,00
	170	37,30 ± 3,47	100	6,40 ± 1,42	17,15	82,85
The third month of fattening	20	109,30 ± 5,68	100	9,50 ± 2,32	8,69	91,31
	50	65,80 ± 3,46	100	8,80 ± 1,37	13,37	86,63
	170	53,30 ± 7,85	100	7,80 ±1,24	14,63	85,37
Last day of fattening	20	137,90 ±20,99	100	10,30 ± 3,14	7,46	92,54
	50	70,50 ±7,43	100	8,20 ± 1,79	11,63	88,37
	170	62,70 ± 5,83	100	8,70 ± 1,31	13,87	86,13
A day after occupation	20	80,60 ± 7,99	100	7,80 ± 2,01	9,67	90,24
	50	38,80 ±6,36	100	6,70 ± 1,33	17,26	82,74
	170	16,90 ± 5,61	100	4,10 ± 1,07	24,26	75,74

DISCUSSION

Dusts in swine confinement houses contain feed grain particles, dried feces and urine, bits of hair, animal dander, pollen, insect parts, bacteria and endotoxins, and fungal spores. Since dusts include both respirable (10 m) and larger inhalable (10-50 μm) particles, lung tissues, large airways, and small airways may all be affected. Short-term health effects in workers and pigs include nonspecific airway hyperactivity and bronchitis with productive cough, chest tightness, and wheezing. Long-term health effects include symptoms typical for airway obstruction and chronic bronchitis. According to Carpenter (1986) and Pickrell (1990) the highest quantities of dust particles capable of penetrating the lungs are less than 5 μm. The data obtained in this study confirms their results. Our examination showed that dust particles of the respirable fraction (< 5 μm) exceeded 70 percent of the total number of dust particles in all samples of the air in the full fattening units. However, in the empty building, one day before the fattening started, their contributions ranged from 32,22 to 61,46 percent. One day after fattening, also in the empty building, the relative amounts did not decrease quickly, but slowly. The portion of respirable dust particles in the empty building one day after fattening ranged from 75,24 to 90,24 percent. These results are in good agreement with Carr (1994) who pointed out that particles of less than 5 μm settle slowly and need only slight air movement to stay aloft. Therefore, it can be concluded that dust particles larger than 5 μm settled quickly which resulted in a decreasing total number of dust particles in the air.

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UKUPAN BROJ ČESTICA PRAŠINE I UDEO RESPIRABILNE FRAKCIJE U VAZDUHU TOVILIŠTA ZA SVINJE

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SADRŽAJ

U vazduhu objekata za tov svinja čestice prašine potiču od samih životinja, ćelija njihove kože, dlake, sasušenih ćelija fecesa i urina, hrane za životinje i drugog usitnjenog materijala. Njihov broj se povećava za vreme uznemiravanja životinja ili pražnjenja objekata i može dostići nivo opasan kako za zdravstveno stanje samih životinja, tako I za zdravstveni status radnika. Količina prašine u vazduhu tovilišta se naročito povećava u toku zimskih meseci kada su objekti zatvoreni. Najmanje jedna trećina ukupnog broja čestica prašine pripada respirabilnoj frakciji koja penetrira plućna tkiva i sve disajne puteve. Uzimajući u obzir sve probleme u vezi sa prašinom u vazduhu tovilišta, cilj rada je bilo ispitivanje udela respirabilne frakcije čestica prašine u objektu za tov svinja kapaciteta 180 tovljenika. Eksperiment je obavljen na farmi svinja u blizini Beograda u toku zimskih meseci 1999. i 2000. godine. Rezultati dobijeni konimetrijskom metodom ukazuju na veliki udeo respirabilnih čestica prašine u svim uzorcima vazduha uzetih sa visine od 20, 50 I 170 cm iznad poda, kao i u svim fazama tova u objektu punog smeštajnog kapaciteta.