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Effect of Manual Feeding on the Level of Farmer's Exposure to Airborne Contaminants in the Confinement Nursery Pig House

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Abstract: The objective of the study is to demonstrate an effect of manual feeding on the level of farmer's exposure to airborne contaminants in the confinement nursery pig house. The levels of all the airborne contaminants besides respirable dust, total airborne fungi and ammonia were significantly higher in the treated nursery pig house with feeding than the control nursery pig house without feeding. Although there is no significant difference in respirable dust and total airborne fungi between the treatment and the control, their concentrations in the treated nursery pig house were also higher than the control nursery pig house. The result that the level of ammonia in the treated nursery pig house is lower than the control nursery pig house would be reasoned by the mechanism of ammonia generation in the pig house and adsorption property of ammonia to dust particles. In conclusion, manual feeding by farmer increased the exposure level of airborne contaminants compared to no feeding activity.

Key words: Manual feeding, Confinement nursery pig house, Farmer's exposure, Airborne contaminants

Introduction

In general organic dust released by feeding feedstuff is recognized to have an adverse effect on farmer's health[1, 2]. Furthermore, because the dust particles have a property to adsorb gaseous compounds and airborne microorganisms[3, 4], they play a role in carrying them to farmer's mouth and nose. If farmer work without wearing respirator, the hazardous substances absorbed at dust particle are inhaled easily and then deposited to farmer's respiratory system, which can be a potential cause to provoke serious respiratory diseases such as asthma, bronchitis and pneumonia[5, 6].

Currently the confinement type of pig house has been widespread in Korea because it guarantees high performance of pig rearing in terms of conserving pertinent thermal indoor environment even in extreme winter season. However, if inadequate ventilation is applied to the confinement pig house, poor indoor air quality would be formed due to accumulation of airborne contaminants[7], implicating severe work environment enough to cause work-related diseases.

Actually there is little need for labor to operate current pig production system because most of the confinement pig houses are constructed automatically, indicating that the exposure level of farmer to airborne contaminants would probably not be acute. Nevertheless, in case of the confinement nursery pig house relatively much labor is still essential because nursery pigs are very sensitive to environmental factors such as temperature and relative humidity. In addition nursery pigs should be fed with the meal type of feedstuff because of digestion capability of nursery pig. When fed, it results in more particles dispersion into air than the pellet type of feedstuff supplied to the growing or finishing pigs[8]. This fact alludes that farmer would be exposed to considerable airborne conta-

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minants when they feed nursery pigs with meal type of feedstuff manually.

Previously diverse studies were performed to report that dust particle derived from feedstuff is primary origin to evolve farmer's work-related illness[9–12]. However, there are little information to actually demonstrate how much manual feeding activity of farmer increases exposure level to airborne contaminants compared with no feeding activity. The objective of the study, thus, is to evaluate an effect of manual feeding and meal type on the level of farmer's exposure to airborne contaminants in the confinement nursery pig house in comparison with the control of no manual feeding.

Materials and Methods

Experimental design

The confinement pig house used for experiment was located at the stock farm in college of agriculture, Seoul National University. It comprised two nursery rooms whose dimension was 4.6 m(L) × 12.0 m(W) × 3.0 m(H), respectively. One of both was a control room where no feed was supplied for experimental period and the other was a treatment room where manual feeding by farmer was conducted. The nursery room had a 0.45 m deep manure pit under a fully slatted floor with a pit surface area of 23 m^2. There were 5 pens (1.9 m × 2.4 m × 0.7 m), installed with open partitions and constructed from galvanized steel spindles 3.7 cm apart, on either side of a 0.8 m wide central alley. The floor consisted of slats. The inside of the house was insulated with 0.8 mm steel plate and 50 mm styrofoam in the side walls and ceiling. The detailed layout of experimental housing is well shown in Fig. 1.

Ventilation mode in the confinement two nursery rooms is a negative pressure system. The air entered the room via two perforated ducts(Φ 25 cm) located below the ceiling and was discharged through perforated twelve holes(Φ 5 cm); separated 80 cm apart; downwards into the pigs in the pens. The 70 cm-diameter wall exhaust fan in the room removed the stale air. Fundamentally an automatic controller adjusted the wall ventilation rate based on the inside room temperature and relative humidity.

Ten to twelve crossbred (Landrace × Yorkshire × Duroc) nursery pigs with the approximately average weight of 4–6 kg were randomly housed in each pen. All pigs were feeder-fed at meal type of crude protein corn-soybean based diet. The feeders were filled by hand and the pigs were given ad libitum access to feed and water supplied by a nipple. In the treatment room the farmer fed nursery pigs when air sampling started whereas the feed was supplied to nursery pigs by the farmer in the control room after air sampling was finished.

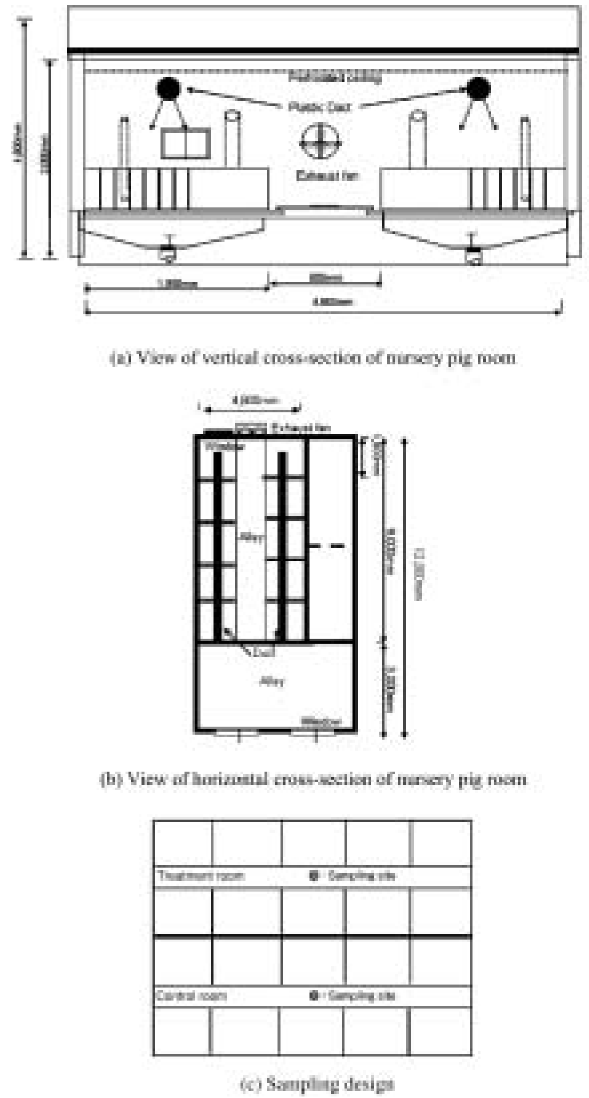

Fig. 1. The layout of experimental nursery pig house.

Measurements

Measurement period are total 30 d from December to February in 2005. Air samplings were taken at three locations, the middle of the central alley and both sides of pen, near 0.15 m above the floor as the farmer's breathing zone. Sampling time on experimental day was from 9:00 am to 5:00 pm, which reflects general day-averaged working time. The airborne contaminants, besides dust sampled for 8 h, were measured three times at 4 h intervals for 8 h and then their average was considered as representative value of the one day experiment.

Total and respirable dust were measured by the gravimetric method. Glass fiber filters (37 mm diameter, 0.8 μm pore size, Nuclepore Corp, Calif., USA) were dried in a desiccator for 24 h and weighed, under controlled atmosphere to avoid rehydration, before and after collecting dust with a microbalance (Ohaus model

AP250D, Switzerland). The flow rate for collecting dust was precalibrated to 2.0 l/min for total dust and 1.7 l/min for respirable dust, respectively. Air sampling was done with low volume sampling pump (Model 71G9, Gillian Corp., NJ, USA) for approximately 8 h. Total particles were collected in close-faced plastic cassette (Nuclepore Corp., Calif., USA) and respirable fractions were collected through 10 mm cylcone preselectors (Gillian Corp., NJ, USA). Control filters were brought to the sampling site and exposed, but not subjected to sampling, and weighed according to the same procedure.

One-stage viable particulate cascade impactor (Model 10-800, Andersen Inc., USA), set at flow rate of 28.3 l/min^{-1}, was used for sampling airborne microorganisms. Before sampling, the inside of the sampler was disinfected with 70% alcohol and then was inserted with the agar plate according to collection stage. The agar media for culturing total airborne bacteria, gram negative bacteria and fungi were the trypticase soy agar media (Lot 2087730, Becton Dickinson and Company, USA), the modified conradi agar media (Lot 2077810, Becton Dickinson and Company, USA) and the 2% Malt extract agar (Lot 3111376, Becton Dickinson and Company, USA), respectively. The culture media for which sample collection were finished were immediately taken to the microbe laboratory and were cultured in the incubator for 1–2 d under a 37˚C condition for bacteria and for 3–5 d under a 20–25˚C condition for fungi, respectively. After incubating was finished, colony counting was made on plates including between 30 and 300 colonies. Concentrations of airborne microbes were then calculated from the number of colonies, the volume of air sampled, and the dilution factor.

Analysis of ammonia and hydrogen sulfide was performed according to the analytical method recommended by NIOSH[13]. By air sampling pump (Model 71G9, Gilian Instrument Corp., NJ, USA) adjusted at 2.0 l/min of flow rate, air was collected for 10–20 min into the all-glass impinger 30 (Ace Glass Inc., Vineland, USA) including the absorption fluid (10 M*l*, 0.1N-H_2SO_4 solution) for ammonia and into charcoal tube (Gilian Instrument Corp., NJ, USA) for hydrogen sulfide, respectively. After sampling, the absorption fluids and charcoal tubes were carried to laboratory and then analyzed with Ion Chromatography (761 Compact IC, Metrohm, Switzerland). Odor concentration index was measured with a portable digital odor sensor (XP-329, Cosmos, Japan).

Thermal factors, inside temperature and relative humidity, were monitored at interval of 10 min in real time through the hybrid recorder (MV 200, Yokogawa Instrument, Japan) and the data were saved in the on-line computer simultaneously.

Data analysis

Student paired *t*-test, by means of SAS package program[14], was executed to significantly validate the difference of concentrations of airborne contaminants between the treatment nursery pig house with feeding and the control nursery pig house without feeding.

Results

Figure 2 shows the levels of airborne contaminants in the treated nursery pig house with feeding and the control house without feeding. The mean total dust concentrations were 2,449 (± 810) $\mu g/m^3$ in the treated nursery pig house and 1,639 (± 1,238) $\mu g/m^3$ in the control house, respectively ($p<0.05$). The averaged respirable dust concentrations in the treated and the control nursery pig house were 515 (± 325) $\mu g/m^3$ and 472 (± 216) $\mu g/m^3$, respectively. However, there was no significant difference in the level of respirable dust between treated and control nursery pig house ($p>0.05$). The mean concentrations of bioaerosol, total airborne bacteria, fungi and gram negative bacteria, in the treated and control nursery pig house were 2.57×10^6 ($\pm 1.12 \times 10^6$) cfu/m^3 and 1.34×10^6 ($\pm 8.24 \times 10^5$) cfu/m^3, 3.04×10^4 ($\pm 1.46 \times 10^4$) cfu/m^3 and 2.89×10^4 ($\pm 1.13 \times 10^4$) cfu/m^3, and 2.18×10^5 ($\pm 1.35 \times 10^5$) cfu/m^3 and 1.15×10^5 ($\pm 7.64 \times 10^4$) cfu/m^3, respectively. The significant differences in the total airborne bacteria and gram negative bacteria between the treated and control nursery pig house were found ($p<0.05$) but there was no significant difference in the total airborne fungi ($p>0.05$). The mean odor concentration index between the treated and control nursery pig house were 431 (± 128) and 319 (± 169), respectively, representing that the difference was highly significant ($p<0.01$). The averaged concentrations of ammonia and hydrogen sulfide in the treated and control nursery pig house were 3.92 (± 2.1) ppm and 4.23 (± 1.73) ppm ($p>0.05$), and 56.01 (± 18.2) ppb and 39.24 (± 25.6) ppb ($p<0.05$), respectively. Except for ammonia, generally the levels of all the airborne contaminants in the treated nursery pig house were higher than those in the control nursery pig house.

Discussion

All of the airborne pollutants concentrations, besides respirable dust, total airborne fungi and ammonia, were significantly higher in the treated room than the control room. This would be caused by an effect of feeding. When the feeding occurs, abundant organic dust particles originated from feed would disperse into the air and be suspended. Because the trajectories of dust particles having a diameter greater than 1 μm, especially, do not close-

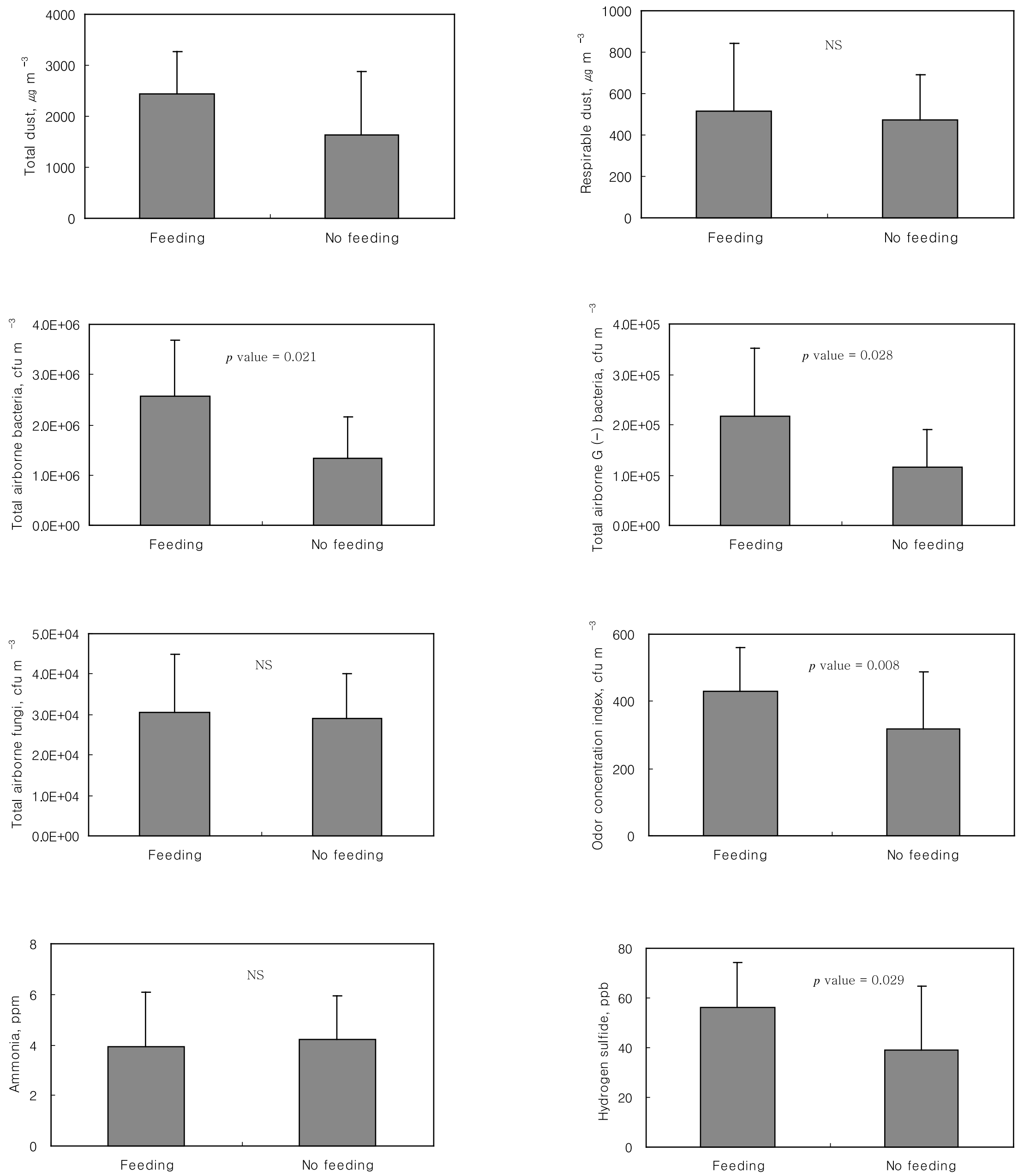

Fig. 2. The levels of airborne contaminants between the treated nursery pig house with feeding and the control nursery pig house without feeding.

ly follow the streamlines within an airspace[15], they are not exhausted outside pig house by ventilation but are suspended in air for a long time or deposited on the floor due to gravitational sedimentation. Consequently, concentration of total dust in the treated room was higher than the control room. Also, because dust particles easily adsorb and carry the gases and airborne microorganisms[3, 4], generally concentration of airborne contaminants in the treated room would be probably higher than the control room.

The finding that no significant difference in respirable dust, total airborne fungi and ammonia was found between the control and treated room would be explained by the following reasons. Because respirable dust comprises particles having a diameter smaller than 10 μm and then follows air pattern formed by ventilation in contrast with total dust including all the particles regardless of particle size[16], the particles corresponding to respirable size would be not deposited to floor but suspended and then exhausted outside the pig house.

Four assumptions for total airborne fungi could be made. First, the origin of airborne fungi would differ from that of airborne bacteria. Lacey[17] reported that viable fungal spores can readily exist in an isolated state whereas airborne bacteria can occur on dried saliva and skin particles from humans and animals. Based on the fact, bacteria other than fungi would probably be predominantly present in dried meal feed. Second, the environmental factors such as temperature and relative humidity can affect the survival of airborne bacteria and fungi. Until now, there were conflicting opinions on effect of temperature and relative humidity on the survival of airborne microorganisms[18, 19]. Because the environmental condition for airborne survival, however, would be definitely different between bacteria and fungi, this somewhat would provide a ground with the above experimental result. Third, it is widely assumed that bacteria other than fungi would be easily adsorbed on dust particles. Fourth, the liquid impinger technique utilized in this study for collecting airborne microorganisms shows little collection efficiency on fungi because fungus spores are generally hydrophobic and difficult to collect in liquid media[20].

In ammonia, the following assumptions could support the above experimental result. One would be the mechanism of ammonia generation in the pig house. Ammonia is produced as a consequence of bacterial activity involving organic N substrates in the pit manure[21]. Therefore, the feeding operation would have little effect on variation of ammonia concentration in the pig house. The other would be difference of adsorption to the surface of dust particles between ammonia and other gases. Generally, ammonia readily adsorbs into the surface of particles[22, 23]. However, this experimental result indicated that ammonia did not adsorb into particles whereas hydrogen sulfide did. Further researches for evaluating degree of adsorption of ammonia and hydrogen sulfide to the surface of dust particles are needed.

Presently in Korea, the nursery pigs are fed manually, unlike growing/finishing pigs, which are fed by the automated distribution system. The confined working environment has been cited as being a cause of concern as a result of the widespread trend toward increased use of confinement houses for nursery pigs[9]. Therefore, farmers and piglets in the confinement nursery pig house are potentially exposed to more airborne contaminants caused by manual feeding and sequently more liable to illness such as respiratory disease than those in the growing/finishing house[24]. During the winter time, in particular, the situation gets worse because the low ventilation rate is applied to the nursery pig house to maintain the high temperature which is liable to increase the activity levels of the piglets and the ratio of pigs to cubic meter of enclosed space. Also, respirable fraction of dust, a cause of severe respiratory damage, was higher in the nursery pig house than the growing/finishing house because the grain particles were larger than fecal particles and proportionately more abundant in finishing buildings[25]. Donham and Popendorf[23] reported that buildings housing younger pigs were more likely to have hazardous gas levels than buildings housing older pigs. According to them, smaller and younger pigs produce a relatively greater amount of urine and feces per pound body weight than older pigs. In addition, the higher temperature probably enhances the normal degradation of urea, found in pig manure, to ammonia. Consequently, ammonia tends to accumulate more readily in farrowing and nursery pig buildings.

Conclusions

The concentrations of total dust, total airborne bacteria, total gram negative bacteria, odor concentration index and hydrogen sulfide were significantly higher in the treated nursery pig house with feeding than the control nursery pig house without feeding. There is no statistical significance in respirable dust, total airborne fungi and ammonia between the treatment and the control. The respirable dust and total airborne fungi showed higher level in the treatment than the control while the concentration of ammonia was lower in the treatment than the control. Based on the finding of this study, it was concluded that farmer's manual feeding resulted in high exposure level of airborne contaminants as compared with no feeding activity.

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