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# Air quality in swine growing and finishing facilities with different building typologies

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**Key words:**
animal welfare
rural buildings
gas concentration
sound pressure

**ABSTRACT**
The objective of this study was to evaluate the concentration of gases in three swine growing and finishing facilities with different building typologies, regarding floor and dividers. The experiment compared three treatments: pen with water depth, pen with partially slotted floor on the sides, and pen with partially slotted floor on sides and in the center. Measurements of instantaneous concentrations of ammonia ($NH_3$ ppm) and carbon dioxide ($CO_2$ ppm) were taken at animal level. The levels of sound pressure (dB) at animal level and at 1.50 m from the floor were also recorded. It was observed that the pen with water depth was the one with the highest average concentration of $NH_3$. Although there was a significant difference in $CO_2$ concentrations, the observed values are within the limits allowed by the Brazilian standards; thus, it is assumed that the facilities do not cause discomfort in relation to $CO_2$ levels. The pen with water depth possibly caused discomfort to the animals, since the $NH_3$ concentration was above the values that can cause problems to the animals, according to the recommendation of the literature. There was no influence of the type of pen on the sound pressure at any time.

**Palavras-chave:**
bem-estar
construções rurais
gases
pressão sonora

## Qualidade do ar em instalações para suínos em crescimento e terminação com diferentes tipologias construtivas

**RESUMO**
O objetivo do trabalho foi avaliar a concentração de gases em três instalações de crescimento e terminação para suínos, com tipologias construtivas diferentes no que tange ao piso e divisórias. Compararam-se três tratamentos: baia com lâmina d'água, baia com piso parcialmente vazado nas laterais e baia com piso parcialmente vazado nas laterais e no centro. Foram feitas medições das concentrações instantâneas de amônia ($NH_3$, ppm) e dióxido de carbono ($CO_2$, ppm) a nível dos animais; também foram registrados os níveis de pressão sonora (dB) a nível dos animais e a 1,50 do piso. Observou-se que a baia com lâmina d'água foi a que apresentou o maior valor médio de concentração de $NH_3$. Apesar de haver ocorrido diferenças significativas nas concentrações de $CO_2$, os valores encontrados estão dentro dos limites permitidos pelas normas brasileiras, presumindo-se, assim, que as instalações não ocasionam desconforto em relação aos níveis de $CO_2$. A baia com lâmina d'água demostrou proporcionar um possível desconforto aos animais, com nível de concentração de $NH_3$ acima de valores que já podem acarretar problemas aos animais de acordo com o preconizado pela literatura. Não foi observada influência do tipo de piso da baia sobre a pressão sonora em nenhum horário.

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## Introduction

Confined swine are maintained in pens most of their lives; thus, the housing must provide adequate conditions of comfort to the animals. Therefore, it becomes important to search for new information on the different types of floors used in these pens.

Various gases are formed inside the facilities, regardless of the utilized production system, varying only the concentrations, and depending on the concentrations, these gases can be harmful and even lethal to the animals. Gases such as ammonia ($NH_3$), hydrogen sulfide ($H_2S$) and carbon dioxide ($CO_2$) are the most present inside swine facilities (Amâncio et al., 2013). Ammonia is the most important gas, because it can occur at very high levels, irritating the respiratory system, leading to behavioral and physiological alterations, reduction in food consumption and weight gain, and possibly affecting the health of animals and workers (Paulo et al., 2009; Kiefer et al., 2010).

The quantification of gas production in production systems is a global concern, since it can affect the environment, health of people involved in the production processes and even alter animal performance (Inoue et al., 2012).

Research conducted with swine has demonstrated that the study of vocalization and sound pressure levels is an innovative and non-invasive method that can indicate the responses of the animal in adverse situations (Borges et al., 2010; Castro et al., 2013; Moura et al., 2008). These methodologies make possible to evaluate the situation of the environment where the animals are (Miranda et al., 2012), since the vocalization is the expression of their specific state (Dupjan et al., 2008).

In this context, this study aimed to evaluate the concentration of gases and the sound pressure in three swine growing and finishing facilities with different building typologies regarding the floor and dividers.

## Material and Methods

The study was carried out in a commercial swine farm (*Granja Niteroi*) (21º 11' 37" S; 45º 02' 49" W; 918 m), in the municipality of Lavras-MG, Brazil, from June to September 2014, during the winter.

The climate of the region, according to Köppen's classification, is Cwa, i.e., rainy temperate (mesothermal) with dry winter and rainy summer, subtropical.

The evaluated raising system was intensive confinement, in which the animals do not have access to the outside of the facilities. The thermal environment and air quality of facilities with swine in growing and finishing stages were evaluated.

The animals were housed in pens as follows: with mean weight of 28.69 kg (pens with water depth, WDP); 28.75 kg (pens with partially slotted floors on the sides, SLS) and with 28.5 kg (pens with partially slotted floor on sides and in the center, SLC). The animals remained in the pens during the growing and finishing stages, reaching final mean weights of 83.47 kg (WDP pen), 85.47 kg (SLS pen) and 87.67 kg (SLC pen).

The animals were housed in masonry barns covered with fiber-cement roofing, supporting structures in reinforced concrete, concrete floor and East-West orientation. Each pen was equipped with two automatic feeders and four nipple drinkers, with total area of 72 m² (8 x 9 m), ceiling height of 3 m, containing 72 animals each. The WDP pen had, on one of its sides, a lowering on the concrete floor (1 m wide and 10 cm deep), filled with water, and was fenced by masonry dividers with ceramic bricks covered with a layer of concrete render and painted in white. The SLC pen had dividers made of steel wire ropes, ceiling height of 3 m and concrete floor, with sides made of slotted precast concrete plates. The SLS pen had masonry dividers with a layer of cement render painted in white, concrete floor, with sides and center made of slotted concrete plates. Figure 1 shows the arrangement of the pens through the floor plan.

Data relative to the ambient thermal comfort in the pens and outside were automatically collected using data loggers (Hobo, model U12-013), with accuracy of ± 0.5 ºC. These devices recorded the dry bulb temperature, relative air humidity and black globe temperature in intervals of five minutes. The data loggers were positioned inside the facilities at a height of 1.20 m from the floor.

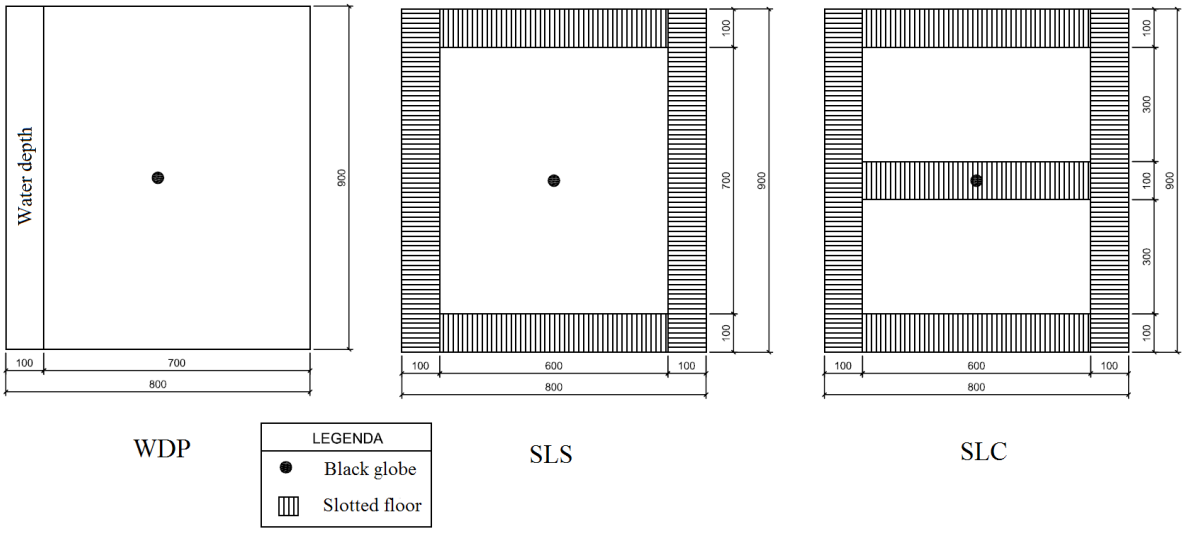


Figure 1. Floor plan of the pens (WDP: Water depth, SLS: slotted floor on the sides and SLC: slotted floor in the center and sides)

The concentration of the ammonia gas ($NH_3$) was measured using a Testo® sensor, with "electrochemical principle", 1-ppm resolution and accuracy of ±1 ppm, which detects the instantaneous concentration in a measuring range from 0 to 100 ppm, whose cell was calibrated in a company registered by Inmetro. Each collection of carbon dioxide ($CO_2$) was performed using a Testo® sensor, model 535, with "infrared principle", 1-ppm resolution and accuracy of ±50 ppm, which detects the instantaneous concentration in a measuring range from 0 to 10,000 ppm. The concentrations of the gases were measured at three different times of the day (9, 12 and 15 h) inside each pen.

The mean level of sound pressure (dB) was obtained using a decibel meter (DEC-460, Instrutherm). The instrument has resolution of 0.1 dB and accuracy of ±1.5 dB, operating in the compensation scale "A". Noise data were collected at two heights (animal level (0.60 m) and 1.50 m from the floor) at three times of the day (9, 12 and 15 h), in the center of the pen.

The obtained results of the noises were used to make boxplot graphs considering the values observed at animal level, using the statistical package Minitab® 16.1.0.

The data relative to the thermal environment were subjected to analysis of variance using the F test and the means were then compared by Tukey test at 0.05 probability level. For this, the analysis was conducted in a randomized block design with split plots, in which the types of floor represented the plots, the evaluation times represented the subplots and the days of collection represented the blocks. The results were obtained using the statistical program Sisvar 5.3 (Ferreira, 2008).

The gases ($NH_3$ and $CO_2$) and noises, due to the non-parametric character of the variables, were subjected to descriptive analysis and the medians of treatments were compared by the confidence interval at 95% significance level (CI = 95%). The results were obtained using the statistical program Minitab® 16.1.0.

## Results and Discussion

There were statistical differences ($p < 0.05$), based on the confidence interval of the median (Table 1), in concentrations of $NH_3$ and $CO_2$, which varied between pens and between the analyzed times. Regarding the times, in the WDP pen, there were differences for the gases, which showed the same trend of results, with an increase in the afternoon period. At 12 and 15 h, there were the highest values, statistically equal, followed by the value found at 9 h, which was also statistically equal to that of 12 h.

According to Popescu et al. (2010), $NH_3$ production and release are generally influenced by temperature and relative air humidity. The relative air humidity in the WDP pen was the highest in comparison to the others (Table 2), which explains the highest $NH_3$ concentrations found in this treatment. The black globe temperature in the WDP pen was the lowest one, in the comparison to all treatments.

Regarding the ambient temperature and black globe-humidity index (BGHI), the values in the WDP pen did not differ from those observed in the SLS, being lower than those found in the SLC. In the present study, the observed BGHI values are below the one found by Turco et al. (1998), who mentioned that the upper limit condition of thermal comfort of the BGHI for adult swine is 72.

The SLS pen showed statistically equal concentrations of $NH_3$ and $CO_2$ between the times, while SLC exhibited equal concentrations between the times for the gas $NH_3$.

The observed $NH_3$ concentrations are below the recommendation for animals by the norms - Commission Internationale du Gene Rural - CIGR (2002), of 20 ppm. NIOSH (1996) considers that the maximum concentration of the gas must not exceed 25 ppm, but at certain times (12 and 15 h) in the WDP pen, the $NH_3$ concentration exceeded the limit recommended by Heber et al. (2002), who consider that concentrations above 10 ppm can harm animal health and growth. Barker et al. (2002) report that the exposure to concentrations above 6 ppm lead to mucosal irritation and exposures to more than 20 ppm can cause eye irritation and respiratory problems. In the present study and at all times of evaluation, in the WDP and SLS pen, the $NH_3$ levels were higher than 6 ppm, indicating a probable discomfort to the animals.

Amâncio et al. (2013), studying the $NH_3$ concentration in swine nursery during the winter, although with slightly different typologies than growing and finishing, also observed significant difference in the mean concentration of this gas for the different times evaluated, with higher means in the last times of evaluation (13 to 15 h).

Regarding the $CO_2$ levels in the present study, the SLC pen also showed differences between the times and the highest

Table 1. Concentrations of gases (ppm) observed along the day in swine growing and finishing facilities with floors with water depth (WDP), slotted on the sides (SLS) and slotted in the center and sides (SLC)

| Variables (ppm) | Pens | Time | | |
|---|---|---|---|---|
| | | 09:00 | 12:00 | 15:00 |
| $NH_3$ | WDP | 7.0 bA | 10.0 abA | 12.5 aA |
| | SLS | 7.0 aA | 7.5 aAB | 7.5 aAB |
| | SLC | 5.0 aA | 5.0 aB | 6.0 aB |
| $CO_2$ | WDP | 738.5 bA | 818.0 abA | 1114.5 aA |
| | SLS | 785.0 aA | 868.5 aA | 913.5 aA |
| | SLC | 618.0 aA | 482.0 bB | 541.0 abB |

Medians followed by the same letter, lowercase in the row and uppercase in the column, do not differ by the confidence interval CI = 95%

Table 2. Mean values of environmental variables observed during the evaluated period, along the day, in swine growing and finishing facilities with floors with water depth (WDP), slotted on sides (SLS) and slotted in the center and sides (SLC)

| Variables[1] | Pen | | |
|---|---|---|---|
| | WDP | SLS | SLC |
| RH (%) | 68.5 a | 64.1 c | 66.2 b |
| Tbg (ºC) | 19.9 c | 20.5 b | 21.2 a |
| Tdb (ºC) | 19.8 b | 19.9 b | 20.6 a |
| BGHI | 66.2 b | 66.7 b | 67.3 a |

[1]Relative air humidity (RH); Black globe temperature (Tbg); Dry bulb temperature (Tdb); Black globe-humidity index (BGHI); Means followed by the same letter in the row do not differ by Tukey test ($p > 0.05$)

concentrations were recorded at 9 and 15 h, with a reduction in $CO_2$ concentration at 12 h. This pen is characterized for being the most open (slotted floors and side dividers made of steel wire ropes), allowing a greater renewal of the air in the micro-environment, notably in this hotter period, proportionally reducing the levels of $CO_2$. Thus, the lowest $CO_2$ concentrations occurred at 12 and 15 h (482 and 541 ppm, respectively) in the SLC pen, compared with the others.

For the time of 9h, there was no statistical difference in the concentration of the gases between the studied pens. For the times of 12:00 and 15:00 h, the $NH_3$ concentration was higher in the WDP pen, compared with the SLC, but the values in the SLS pen were statistically equal to those in WDP and SLC. For $CO_2$, the SLC pen showed lower concentrations at 12 and 15 h, compared with the others.

The $CO_2$ concentrations found in the present study are lower than those that can harm animal and human health, and the norm NR-15 (Brasil, 1978) establishes the maximum limit of 3,900 ppm for workers. According to Larry et al. (1994), the $CO_2$ is considered as excessive when the concentration is above 3,000 ppm and, for concentrations of up to 5,000 ppm, it can be tolerated for brief periods by animals.

Sousa et al. (2014), evaluating $CO_2$ concentrations, but using overlapping beds, for swine in the finishing stage, also obtained results below the concentration that can cause damages to animal health, at all evaluated times (9 h 00 min; 11 h 30 min; 14 h 00 min and 16 h 30 min).

In the present study, there was no statistical difference in the confidence interval and median at 95% probability level in the sound pressure (Table 3) for any of the times or heights (animal level and 1.50 m from the floor).

The means observed both at animal level and 1.5 m from the floor for all treatments and all evaluated times are within the range of noise emission tolerance established by the norm NR-15 (Brasil, 1978), of 85 dB for workers, demonstrating that there are no insalubrious conditions for the workers and that they can stay for longer periods under the conditions presented in the study. Tolon et al. (2010) mention that, because there are no specific norms that evaluate the limit of tolerance to the noises emitted by the animals, the same noise levels indicated for humans have been adopted as ideal.

Sampaio et al. (2005) claim that the behavior of the noise emitted by the animals along the day is related to the higher or lower well-being for swine. Therefore, since there was no difference between the noise levels, with values below the recommendations and BGHI within adequate levels, it can be assumed that the animals were in a comfort condition.

Table 3. Noise level measured in swine growing and finishing facilities with floor with water depth (WDP), slotted on sides (SLS) and slotted in the center and sides (SLC)

| Variables[1] (dB(A)) | Pens | Time | | |
|---|---|---|---|---|
| | | 09:00 | 12:00 | 15:00 |
| Noise AL | WDP | 67.7 Aa | 67.60 Aa | 70.8 Aa |
| | SLS | 69.3 Aa | 68.90 Aa | 68.9 Aa |
| | SLC | 68.0 Aa | 67.65 Aa | 69.3 Aa |
| Noise 1.5m | WDP | 69.3 Aa | 70.15 Aa | 73.4 Aa |
| | SLS | 71.9 Aa | 71.65 Aa | 71.3 Aa |
| | SLC | 70.4 Aa | 69.70 Aa | 71.0 Aa |

[1]Noise AL (dB(A)) - Noise measured at animal level; Noise 1.5m (dB(A)) - Noise measured at 1.5 m from the floor; Medians followed by the same letter, lowercase in the row and uppercase in the column, do not differ by the confidence interval CI = 95%

## Conclusions

1. There was no significant difference in $CO_2$ concentrations for the different typologies of facilities.

2. The pen with water depth led to a possible discomfort to the animals, with $NH_3$ concentration above the values that could cause problems.

3. There was no influence of the analyzed building typologies of the pens on the sound pressure, at any of the evaluated times.

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