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BROILER GAS SPATIAL VARIABILITY ON DIFFERENT MINIMUM VENTILATION SYSTEMS

D.J. MOURA[1], T.M.R. CARVALHO[1], Z.M. SOUZA[1], I.A. NÄÄS[3], G.S. SOUZA[1]

[1] D.J. Moura, School of Agriculture Engineering, State University of Campinas, Brazil, daniella.moura@feagri.unicamp.br
[1] Z.M. Souza, zigomarms@feagri.unicamp.br
[1] T.M.R. carvalho, thaylamrcarvalho@hotmail.com
[1] G.S. Souza, gsdsouza@hotmail.com
[1] I.A. Nääs, irenilza@agr.unicamp.br

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ABSTRACT The knowledge of the spatial variability of climatic attributes and the use of kriging maps can help livestock management of lodged animals. The objective of this research was to characterize the spatial variability of the ammonia concentration – NH_3 and carbon dioxide concentration – CO_2 in broiler houses during brooding phase (1 to 14 days old broilers) using geostatistics. Two different minimum ventilation systems were studied, such as treatment 1, exhaust fans + flags (Dark House) and treatment 2, natural ventilation. The studied attributes, NH_3 and CO_2 concentrations were sampled at 80 points, in regular spacing, as a grid at bird's height. According to the results, the geostatistical analysis showed that all studied variables were spatially dependent making it possible to find areas with different spatial distribution between both treatments and different studied ages. The maps illustrated that NH_3 and CO_2 concentrations in treatment 1 were greater near the exhaust fans (for 7 to 14 days old birds). On treatment 2, this greater concentration did not happen because of natural ventilation by the side wall curtains. As expected the CO_2 concentration increased with the age of the birds. The results showed inadequate levels (Globalgap, 2007) of CO_2 and NH_3 concentration in treatment 1 that had a greater thermal insulation and less openings when compared to treatment 2 where air changes occurred through the side curtains.

Keywords: Poultry, thermal comfort, minimum ventilation systems, air quality

INTRODUCTION According to Czarick (2007), the minimum ventilation reduces the relative humidity that increase the moisture on the broiler housing litter and helps in reducing the gases concentration (NH_3 and CO_2) achieving a better environment for the broilers health and production. The CO_2 concentration inside broiler housings must remain above 5000ppm, the relative humidity must be above 60% and NH_3 concentration above 20ppm. There are a lot of important variables to improve the air quality on broiler production in ventilation studies. On the first phase, the chicks need supplemental heat and air renewal through a minimun ventilation system. The air quality study is an

important factor to monitor the broilers welfare, health and yield, as far as the sustainability of the overall production.
This work has used the geoestatistics to model the spatial dependence of the NH_3 and CO_2.
The geoestatistics is a tool that allows the data analysis based on their spatial variability (Freitas, 2000). Kriging is a group of geostatistical techniques to interpolate the value of a random field at an unobserved location from observations of its value at nearby locations.
In spatial statistics, the empirical semivariance is described by equation 1:

$$\gamma(h) = \frac{1}{2} E[Z(x_i) - Z(x_i + h)]^2 \quad (1)$$

Where:
Z is a data at a particular location,
h is the distance between data and
γ(h) is the Semivariance

The semivariance is half the variance of the increments $z(xi + h) - z(xi)$, but the whole variance of z-values at given separation distance h (Bachmaier and Backes, 2008).
Faria et al. (2007) used the geoestatistics to determine the spatial variability on the environment of a dairy freestall, evaluating different climatization systems and the result homogeneity of the environment. Miragliotta (2005) also used the geostatistics analysis to evauate the environment variables in a broiler housing that was virtually divided on 132 cells having as objective to evaluate spatial variability of the environment in relation to different ventilation systems and bird density. Miles et al. (2008) used the geoestatistic theory to evaluate the spatial and temporal variability of NH_3 and N_2O flow on the broiler housing litter.
The objective of this research was to evaluate the environment spatial variability in different types of minimum ventilation such as exhaust fans + “flag” system (dark house) and side curtains management on broilers brooding phase (1 to 14 days old).

METHODOLOGY The present research was developed in two broiler housings using different minimum ventilation systems:
- Treatment 1 – T1: Exhaust fans + flags
- Treatment 2 – T2: side curtains management

The birds breeding were Cobb from 1 to 14 days old. The T1 heating system was diesel furnace and T2 heating system was firewood furnace.
The broiler housings were virtually divided on 80 cells on the bird high. The data were collected at 9h00min AM and 5h00min PM, during winter time of 2009. The geoestatistics analysis was used to evaluate the data using software GS+ 7, and software Minitab® to evaluate the variation coefficient. The maps were built using software Surfer®.

RESULTS AND DISCUSSION Figure 1 shows the minimum ventilation systems and the furnaces on both broiler housings.

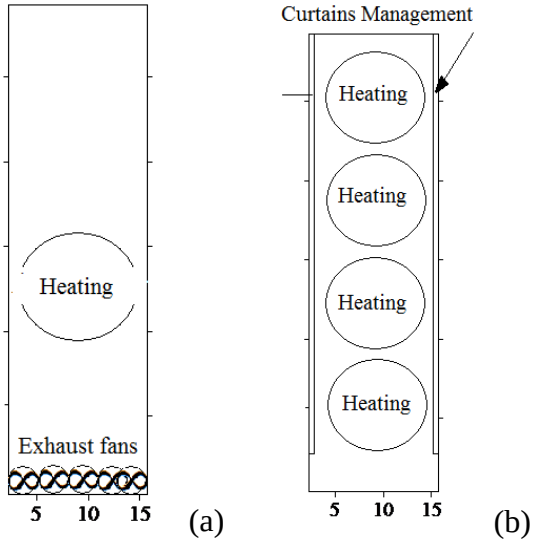


Figure 1. Minimum ventilation systems and heating systems on (a) Treatment 1 and (b) Treatment 2.

Figure 2 and 3, shows the NH_3 and CO_2 concentrations for 1 day old birds at 9:00AM and 5:00PM for both treatments, respectively. The highest values are concentrated in T1, which is the dark house that had the more insulated building showing the highest concentration of NH_3 and CO_2, spetially at 9:00AM.

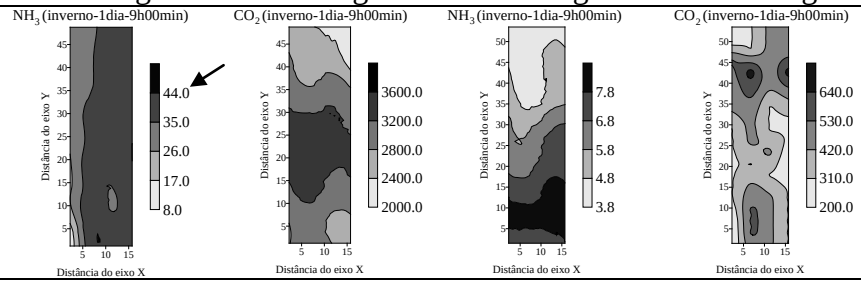
	Treatment 1		**Treatment 2**	
Atributes	**NH_3**	**CO_2**	**NH_3**	**CO_2**
Distribuition	Homogeneous	Homogeneous	Homogeneous	Heterogeneous
Model	Gaussian	Gaussian	Gaussian	Exponential
Spacial dependence	Strong	Strong	Strong	Strong
Maps				

Figure 2. Kriging maps for NH_3 and CO_2 concentration [ppm] at 9h00min AM to 1 day old birds.

At 9h00min AM all the data fitted in Gaussian model and had an homogeneous distribution, with exception of CO_2 in T2 that had an Exponential model and heterogeneous distribution. The natural ventilation system didn't have a good insulation and the ventilation couldn't be controlled.

Figure 3 shows that NH_3 and CO_2 concentrations, for 1day old birds, at 5h00min PM, were within the ideal limits suggested by Globalgap (2007) in both treatments except treatment 1 that NH_3 concentration was above 20ppm. T2 presented homogeneous distribution while T1 presented heterogeneous distribution, and the models fitted a Gaussian model for NH_3 and Spherical model for CO_2 illustrated in Figure 3.

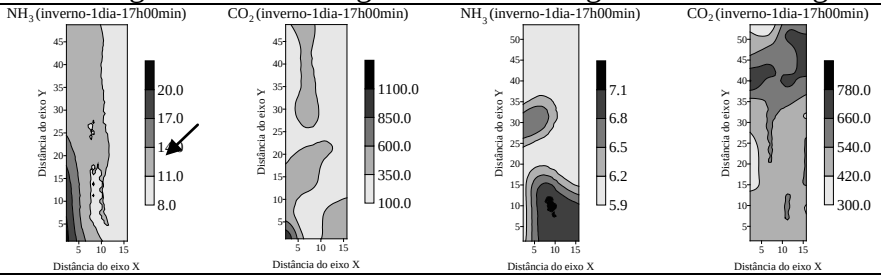
	Treatment 1		Treatment 2	
Atributes	**NH_3**	**CO_2**	**NH_3**	**CO_2**
Distribuition	Heterogeneous	Heterogeneous	Homogeneous	Homogeneous
Model	Gaussian	Spherical	Gaussian	Spherical
Spacial dependence	Strong	Strong	Strong	Strong
Maps				

Figure 3. Kriging maps for NH_3 and CO_2 concentration [ppm] at 5h00min AM to 1 day old birds.

The highest concentration of CO_2 was located where there were more birds since the CO_2 is produced by the bird's respiration. The same results were obtained by Miragliotta (2005) studying negative pressure broiler houses with birds already close to slaughter.

Through the values in Figure 4 and 5 it is noticed that the NH_3 concentration in T1 was above the ideal values suggested by GLOBALGAP (2007) which stipulated a limit of 20 ppm. The CO_2 concentrations in all treatments were within the ideal limits suggested by Globalgap (2007) and Cobb (2008) with a 3000 ppm limit.
It is possible to observe an homogeneous distribution in T1 and T2 for NH_3 concentration and an heterogeneous distribution in T1 and T2 for CO_2 concentration. The semivariograms fitted Gaussian model for NH_3 at 9h00min AM and 5h00min PM.

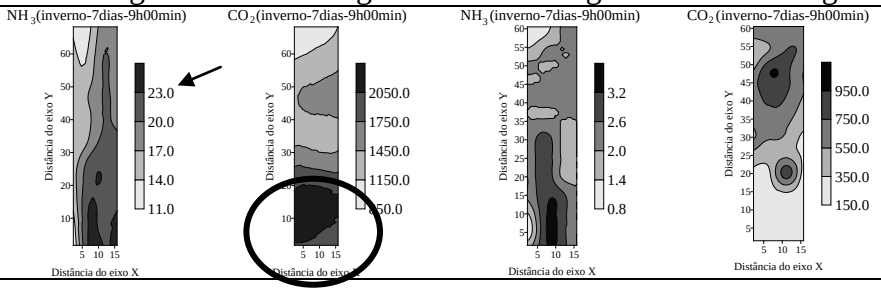
	Treatment 1		Treatment 2	
Atributes	**NH_3**	**CO_2**	**NH_3**	**CO_2**
Distribuition	Homogeneous	Heterogeneous	Homogeneous	Heterogeneous
Model	Gaussian	Gaussian	Gaussian	Gaussian
Spacial dependence	Strong	Strong	Strong	Strong
Maps				

Figure 4. Kriging maps for NH_3 and CO_2 concentration [ppm] at 9h00min AM to 7 days old birds.

Figure 3 and 4 for 7 days old birds, showed a NH_3 concentration of 18,56 ppm for T1 which is considered close to the limit suggested by Globalgap (2007), while the other treatment was within the ideal level. The minimum ventilation was able to renew the air

in relation to CO_2 concentration. However, T1, Dark house, presented the greatest values of gases concentration.

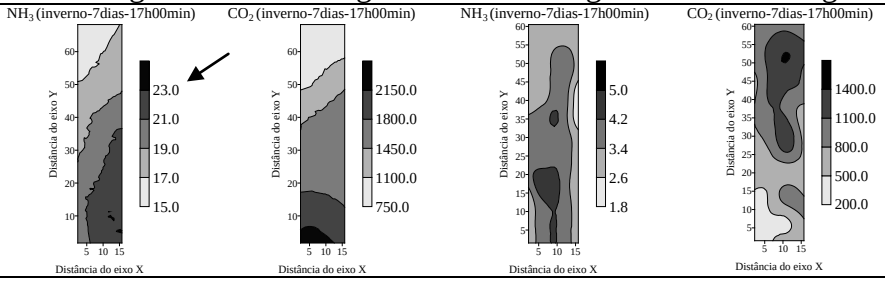
	Treatment 1		Treatment 2	
Atributes	**NH_3**	**CO_2**	**NH_3**	**CO_2**
Distribuition	Homogeneous	Heterogeneous	Homogeneous	Heterogeneous
Model	Gaussian	Gaussian	Gaussian	Gaussian
Spacial dependence	Strong	Strong	Strong	Strong
Maps				

Figure 5. Kriging maps for NH_3 and CO_2 concentration [ppm] at 5h00min AM to 7 days old birds.

Figure 6 and 7 show that the management of exhaust fans was able to maintain air quality in the levels suggested by Globalgap (2007).

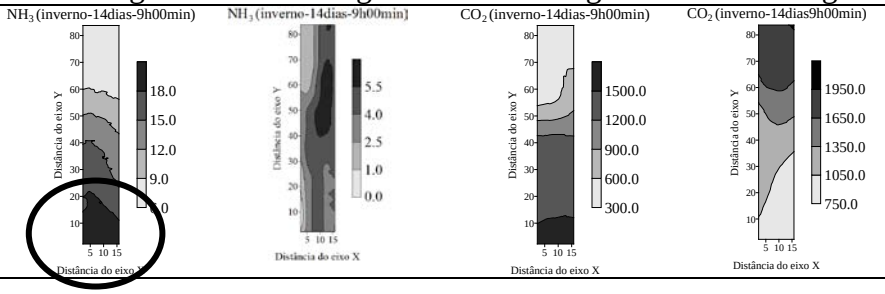
	Treatment 1		Treatment 2	
Atributes	**NH_3**	**CO_2**	**NH_3**	**CO_2**
Distribuition	Heterogeneous	Heterogeneous	Heterogeneous	Heterogeneous
Model	Gaussian	Gaussian	Gaussian	Gaussian
Spacial dependence	Strong	Strong	Strong	Strong
Maps				

Figure 6. Kriging maps for NH_3 and CO_2 concentration [ppm] at 9h00min AM to 14 days old birds.

For 14 days old birds, at 9h00min AM and 5h00min, PM all the semivariograms fitted a Gaussian model for NH_3 and CO_2 in both treatments having homogeneous distribution, while for NH_3 an Exponential model was fitted for T2 having heterogeneous distribution.

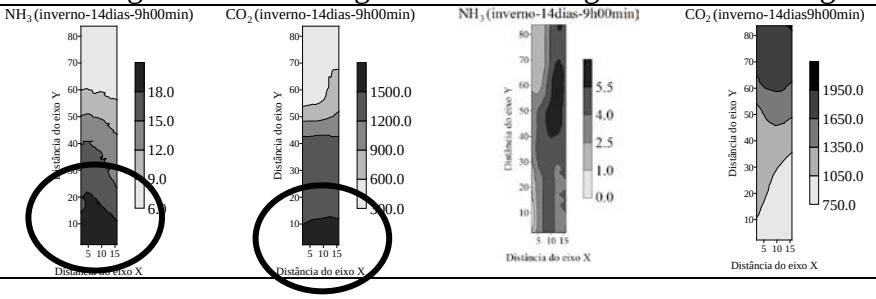
	Treatment 1		Treatment 2	
Atributes	**NH_3**	**CO_2**	**NH_3**	**CO_2**
Distribuition	Heterogeneous	Heterogeneous	Homogeneous	Heterogeneous
Model	Gaussian	Gaussian	Exponential	Gaussian
Spacial dependence	Strong	Strong	Strong	Strong
Maps				

Figure 7. Kriging maps for NH_3 and CO_2 concentration [ppm] at 5h00min AM to 14 days old birds.

The highest concentration of gases in Figure 7, was near the exhaust fans in function of the higher ventilation at 14 days of growth.

CONCLUSION It was observed that the efficiency of the minimum ventilation system is a function of the air flow changes, so, the "flag" system in Dark Houses (T1) presented the worst air quality. The CO_2 and NH_3 concentrations were greater near the exhaust fans since the 7 days of growth. As expected the CO_2 concentration increased with the age of the birds. The results showed inadequate levels (Globalgap, 2007) of CO_2 and NH_3 concentration in Treatment 1 that had a greater thermal insulation and less openings when compared to Treatment 2 where air changes happened through the side curtains.

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