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Abstract

The objective of this study was to examine the temporal variation of greenhouse gas (GHG) concentration in the swine building over both daily and seasonal basis. The air samples were collected every one hour continuously for three days during summer and spring, and analyzed by gas chromatography (GC). Barn temperature was collected and the management practices were also noted. Results showed that methane (CH4) and carbon dioxide (CO2) concentration was related to the internal temperature and ventilation. Daily CH4 and CO2 concentrations varied more during cold weather than warmer weather; nighttime GHG concentration in the gestation building was higher than daytime because of the low air exchange. Average CH4 concentration in the gestation building was 16.67 + 9.88 ppm in spring and 9.25 + 7.64 ppm in summer. Average CO2 concentrations were 2361.65 + 960.96 ppm in spring and 1134.96 + 373.53 ppm in summer.

Keywords

Methane, carbon dioxide, greenhouse gas, swine building

Disciplines

Bioresource and Agricultural Engineering

Comments

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TEMPORAL VARIATION OF GREENHOUSE GAS EMISSION IN GESTATION SWINE BUILDING

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ABSTRACT

The objective of this study was to examine the temporal variation of greenhouse gas (GHG) concentration in the swine building over both daily and seasonal basis. The air samples were collected every one hour continuously for three days during summer and spring, and analyzed by gas chromatography (GC). Barn temperature was collected and the management practices were also noted. Results showed that methane (CH_4) and carbon dioxide (CO_2) concentration was related to the internal temperature and ventilation. Daily CH_4 and CO_2 concentrations varied more during cold weather than warmer weather; nighttime GHG concentration in the gestation building was higher than daytime because of the low air exchange. Average CH_4 concentration in the gestation building was 16.67 $\pm$ 9.88 ppm in spring and 9.25 $\pm$ 7.64 ppm in summer. Average CO_2 concentrations were 2361.65 $\pm$ 960.96 ppm in spring and 1134.96 $\pm$ 373.53 ppm in summer.

KEYWORDS. Methane, carbon dioxide, greenhouse gas, swine building

INTRODUCTION

Livestock production contributes to the climate change by producing greenhouse gas (GHG). It is estimated that global livestock produce 80-100 Tg ($g \times 10^{12}$) of methane (CH_4) per year, which is about 22% of total anthropogenic sources of (CH_4). The GHG from livestock husbandry is emitted from enteric fermentation, buildings, manure storage and treatment, pastures (grazing) and during manure application.

Previous studies were focused on GHG emission coming from enteric fermentation and manure management including the storage of manure, manure treatment and manure application (IPCC, 1996; IPCC, 2000). Knowledge on GHG emissions from animal buildings is limited. Kaharabata and Schuepp (2000) explored the feasibility of measuring the CH_4 emissions from dairy barn by tracer method. Kinsman et al. (1995) measured CH_4 and carbon dioxide (CO_2) emissions from dairy cows. Sneath et al. (1997) measured CH_4, CO_2 and nitrous oxide (N_2O) continuously over a period of seven weeks from swine fattening barn, broiler house and dairy cow barn. The measured emission rates from slurry-based swine fattening barn, broiler house and dairy cow barn were 18, 32, 10 g/day/500 kg live weight for CO_2, 86, 0, 320 g/day/500 kg live weight for CH_4, 0.4 , 0, 0.8 g/day/500 kg live weight for N_2O, respectively. Little is known about the quantity of emissions from gestation swine buildings. In addition, the high gas concentration inside the animal house causes health problems for both humans and animals. Hence, there is a need to investigate the GHG emission from the swine building.

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The major objectives of this study were: to examine the temporal variation (daily and seasonal) of GHG concentration inside the swine building, to accumulate knowledge on GHG concentration inside the buildings, and to provide the reference data for the estimation of GHG emission from a swine building.

MATERIALS AND METHODS

Experimental Swine Gestation Facility

The experimental barns were located in the Hebei provinces. The barns were 12 m x 50 m in size with a west-east orientation. The height of the barn was 2.4 m at the eave level. It has 32 windows (1.0 m x 1.4 m) along both longitudinal walls and spaced at 0.8 m. The barns had partially slatted flooring (15% of pen area) with 34 pens on both sides of the center aisle.

The barn housed 239 gestation pigs. The gestation pigs, 210–250 kg live weight, last 15-16 weeks in the barn. During the whole period, the pigs were provided ground feed of 2.5-3.5 kg per day from one feed dispenser, water was provided ad libitum with a nipper drinker in each pen.

The ventilation system includes two 1.25-meter exhaust fans with a rate of 45,000 m^3/hr and six cooling fans with a rate of 4,800 m^3/hr. The exhaust fans were located in the east end wall. The cooling fans were suspended over the pens at a height of 2.2 m from the floor; the distance between the fans was 16 m. In the summer, the exhaust and cooling fans are turned on continuously. Once the inside temperature reached 28°C, the fogging system of cooling fans turned on. In the winter, the two exhaust fans are turned on for 15 minutes every 4 hrs to provide fresh air, while all the windows were closed to maintain the inside temperature.

The manure collection gutter located beneath the slatted portion of the floor run across the entire length of the building. The depth of the gutter was 0.1 m at the east side and 0.4 m at the west side. The manure in the pen was swept into the gutter and flushed out of building. Flushing was done twice a day.

Measurement

Air samples for measuring CH_4 and CO_2 were taken using a series of aluminized polyethylene bags of 1 L capacity (Daliang Guangming Chemical Research Institute). The air was sampled using a 100mL glass syringe. Sampling inside the barn was done at the center aisle, 0.3 m above the floor. The gas samples were taken at 1-h intervals for three days in August 2003 and March 2004. The outside air was sampled 2 m downwind from the sidewalls at 24-h intervals.

All air samples were analyzed for CH_4 and CO_2 in the laboratory. Gas concentration measurements were carried out using a GC (HP 6890) with flame ionization detector (FID). Calibration was done using standard gases (China National Standard Mass Institute).

The indoor and outdoor temperature and humidity were recorded and related to the gas emission. The inside temperature was measured at 1.5 m from the floor at the same location where the air was sampled. Hobo Pro T/RH (Onset Computer Corporation, U.S.A.) were used for the air temperature and relative humidity measurement. The measurement readings for indoor and outdoor temperature and humidity were taken at 1-h intervals.

RESULTS AND DISCUSSION

Daily Variation of CH_4 Concentration

Figures 1 and 2 show the temperature and CH_4 measurement results for summer and spring, respectively. In general, the inside daily temperature varied more during the warmer weather than colder one. On the other hand, the daily CH_4 concentration varied more during colder weather than warmer weather. This might be because all the windows were open during the summer resulting in higher air exchange rate between the inside and outside environment. Fluctuation in external temperature caused the related change in the inside temperature, and a steady outside background CH_4 concentration resulted in relatively steady inside gas concentration. The daytime and nighttime CH_4 concentrations inside the barn during the summer were 7.86 $\pm$ 3.24 ppm and 11.26 $\pm$ 10.06 ppm, respectively (figure 1). A high CH_4 concentration of 62.75 ppm was measured on the mid-night of August 21 (figure 1) because of the rain and closed windows. During the cold weather, all the windows were closed during the night (20:00 to 7:00), resulting in little air exchange between the inside and outside environment. This resulted in high average CH_4 concentration of 19.89 $\pm$ 10.33 ppm (figure 2). During the day, the gas concentration went down to 11.65 $\pm$ 7.88 ppm because some of the windows along the south side wall were opened and the exhaust fans were turned on enhancing the air exchange. As shown in table 1, the difference between the daytime and nighttime CH_4 concentrations was 43.4% for summer and 70.8% for spring.

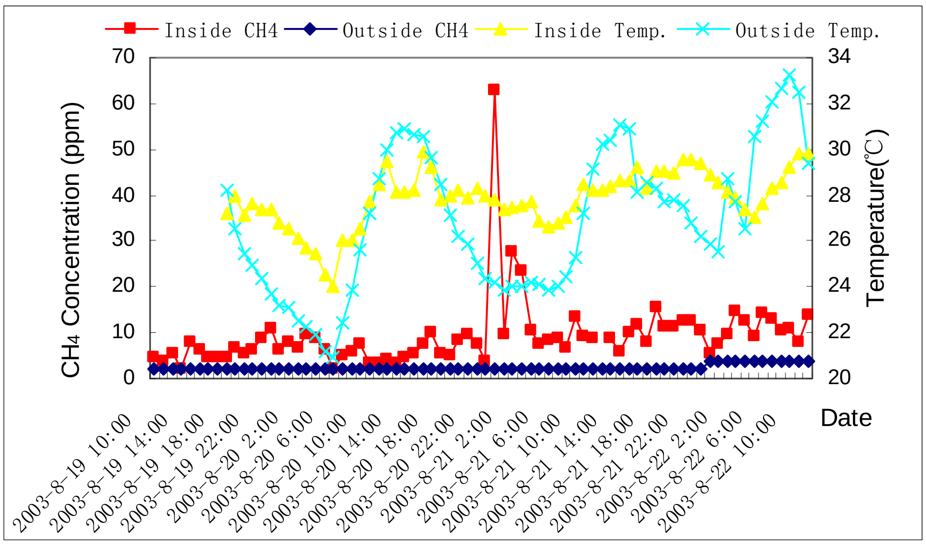

Figure 1. Daily variation in CH_4 concentration and temperature from a swine gestation barn in August 2003.

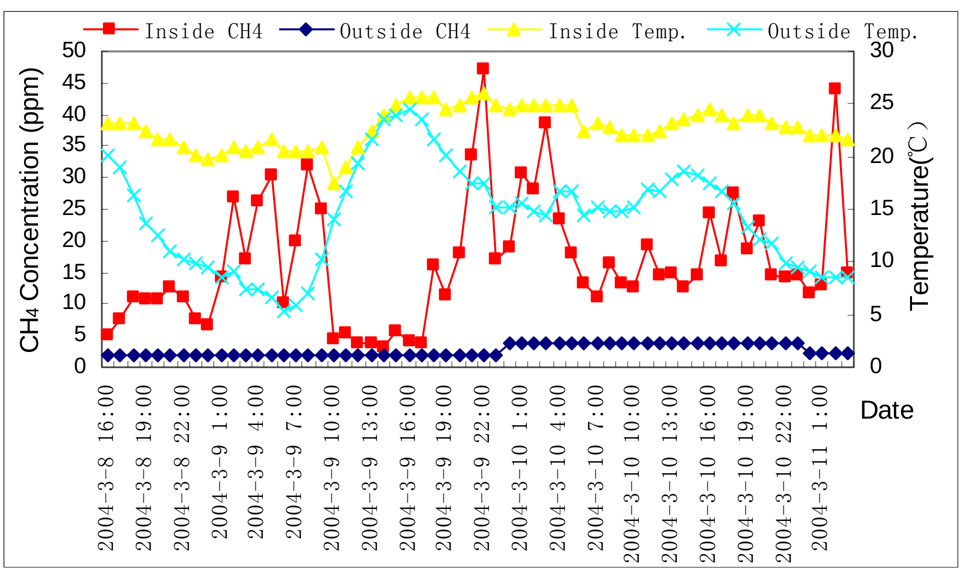

Figure 2. Daily variation in CH_4 concentration and temperature from a swine gestation barn in March 2004.

<u>Daily Variation in CO_2 Concentration</u>

The daily variations in temperature and CO_2 concentration for summer and spring are shown in Figures 3 and 4, respectively. It can be seen that CO_2 concentration behaves in similar way to that of CH_4. In summer, the inside CO_2 concentration was 1,038.59 $\pm$ 367.57 ppm during daytime and 1,237.01 $\pm$ 356.26 ppm during nighttime. The CO_2 concentration difference between day and night was 19.1%. During the cold weather, the average nighttime-inside CO_2 concentration (2,721.77 $\pm$ 868.78 ppm) was 36.4% higher than the average daytime CO_2 concentration (1,995.83 $\pm$ 882.16 ppm) (table 1).

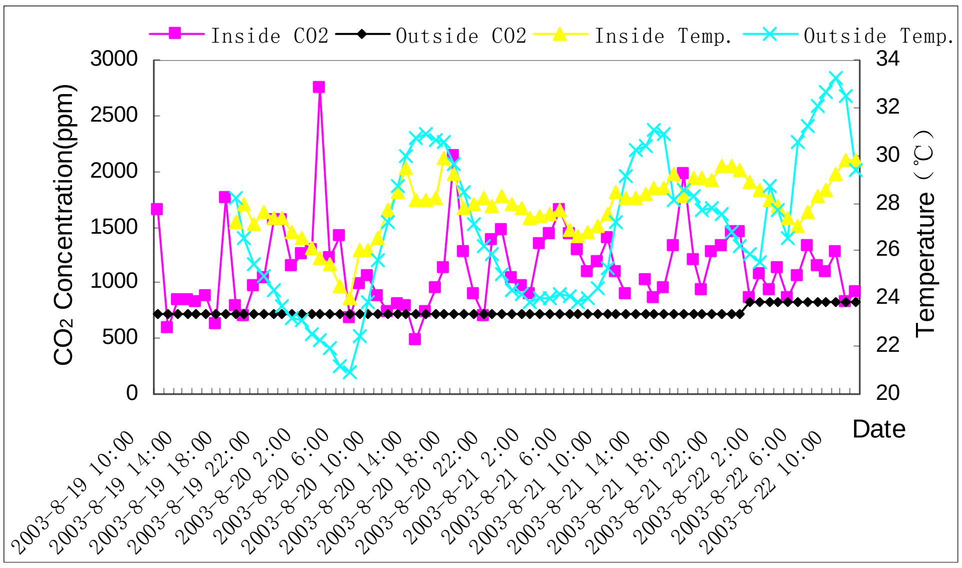

Figure 3. Daily variation in CO_2 concentration and temperature from a swine gestation barn in August 2003

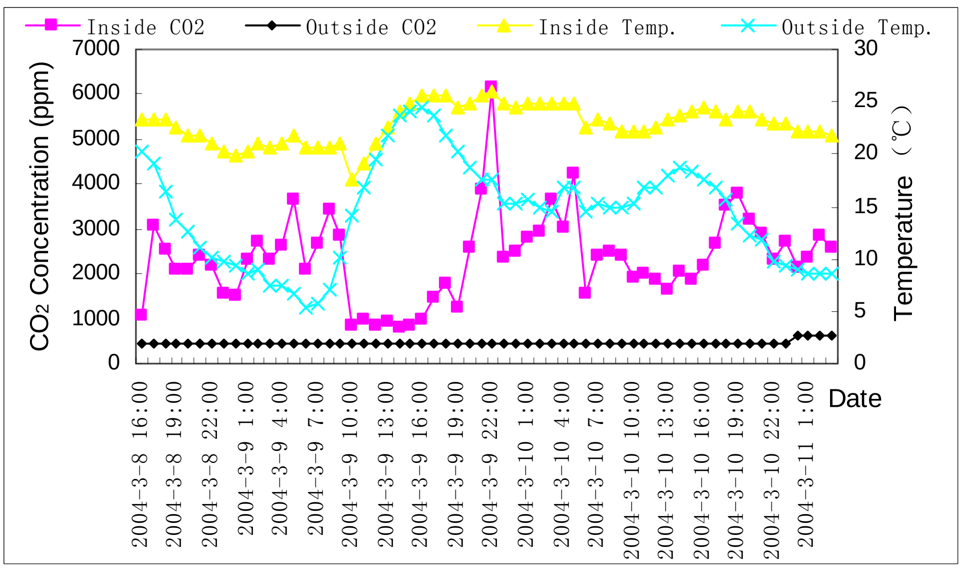

Figure 4. Daily variation in CO_2 concentration and temperature from a swine gestation barn in March 2004.

Table 1. Comparison of CH_4 and CO_2 concentrations during daytime and night time.

Time	Inside CH_4 Concentration (ppm)		Inside CO_2 Concentration.(ppm)		Inside Temp. ( )		Outerside Temp ( )	
	Average	SD	Average	SD	Average	SD	Average	SD
Summer, August 2003								
Day Time Average	7.86	3.24	1038.59	367.57	28.36	0.92	29.11	2.35
Night Time Average	11.26	10.06	1237.01	356.26	27.40	1.26	25.18	2.63
Difference	43.4%		19.1%		-3.4%		-13.5%	
Spring, March 2004								
Day Time Average	11.65	7.88	1995.83	882.60	22.95	1.87	17.54	4.11
Night Time Average	19.89	10.33	2721.77	868.78	22.68	1.83	11.47	3.83
Difference	70.8%		36.4%		-1.2%		-34.6%	

Seasonal Variation in Gas Concentration

The measured gas concentration level changed with the seasons. As shown in table 2, the CH_4 and CO_2 concentrations were high during cold weather (average concentrations: 16.67 $\pm$ 9.88 ppm for CH_4 and 2,361.65 $\pm$ 960.965 ppm for CO_2) than during warm weather (average concentrations: 9.25 ± 7.64 ppm for CH_4 and 1134.96 ± 373.53 ppm for CO_2). The decrease in inside gas concentrations in the swine barn during summer could be explained by the higher ventilation rates; however, the gas concentrations are affected not only by temperature and ventilation rate but also by other factors such as manure handling and the growth of the pigs during the production period. These factors were not taken into account separately in the statistical analyses. Therefore, it should be noted that the values presented here are mean concentrations for these experimental conditions.

Table 2. Comparison of concentrations during summer and spring seasons.

Date		Summer (August 2003)		Spring (March 2004)	
		Inside	Outside	Inside	Outside
Temperature ( )	Mean	27. 84	26.88	22.80	14.44
	SD	1.21	3.12	1.84	4.93
	Max	29.93	33.25	25.95	24.40
	Min	24.01	20.95	17.52	5.40
CH_4 Concentration (ppm)	Mean	9.25	2.49	16.67	2.64
	SD	7.64	0.56	9.88	0.98
	Max	62.75	3.75	47.01	3.83
	Min	2.13	2.23	3.14	1.82
CO_2 Concentration (ppm)	Mean	1134.96	742.88	2361.65	466.86
	SD	373.53	37.77	960.96	41.27
	Max	2747.92	828.14	6130.88	618.85
	Min	479.59	726.06	783.44	451.58

CONCLUSIONS

From the results, it can be concluded that:

1) The variation in CH_4 and CO_2 concentrations has the same pattern as temperature, daily CH_4 and CO_2 concentrations varied more during cold weather than warmer weather;
2) Inside CH_4 concentration was 7.86 ± 3.24 ppm during daytime and 11.26 ± 10.06 ppm during night period in summer; in cold weather, the daytime CH_4 concentration was 11.65 ± 7.88 ppm and nighttime CH_4 concentration was 19.89 ± 10.33 ppm;
3) Inside CO_2 concentration was 1,038.59 ± 367.57 ppm during the day and 1,237.01 ± 356.26 ppm during the night in summer; in spring, the inside CO_2 concentration was 1,995.83 ± 882.16 ppm during daytime and 2,721.77 ± 868.78 ppm during nighttime;
4) Average CH_4 concentrations were 16.67 ± 9.88 ppm in spring and 9.25 ± 7.64 ppm in summer; CO_2 concentrations were 2,361.65 ± 960.96 ppm in spring and 1,134.96 ± 373.53 ppm in summer; and
5) Future work will involve establishing the relationship between gas concentration and ventilation rate.

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