



Assessment of microclimate and gaseous pollutants in dairy and pig sheds in an organised farm

D DIVYALAKSHMI¹, N KUMARAVELU², B SAMUEL MASILAMONI RONALD³,
S MEENAKSHI SUNDARAM⁴ and THANGA THAMIL VANAN⁵

Tamil Nadu Veterinary and Animal Sciences University, Chennai, Tamil Nadu 600 007 India

Received: 19 June 2015; Accepted: 7 December 2016

ABSTRACT

Intensive livestock production is one of the major sources of atmospheric emissions of greenhouse gases. The microclimate of livestock sheds also influences the productivity and shelf-life of livestock products. The present study assessed the gaseous pollutants and microclimate in dairy and pig sheds in an organised farm. Three types of livestock buildings, viz. dairy cow, pig fattener sty and farrowing pen were selected for the study purpose. Microclimatic data was recorded daily during rainy, winter and summer seasons periodically. Indoor gaseous pollutants, viz. carbon dioxide (CO₂), ammonia (NH₃) and methane (CH₄) were recorded using multi gas monitor. The assessed THI values were higher than the ideal value of 72 in all the livestock sheds irrespective of the seasons. With regards to gaseous pollutants, CO₂ and NH₃ emissions were less in the afternoon when compared to morning sessions in contrast to CH₄ which was higher in afternoon sessions in all the sheds. All the three gaseous pollutants were within the recommended threshold limit level.

Key words: Ammonia, Carbon dioxide, Livestock sheds, Methane, Microclimate

Animal husbandry is one of the major sources of atmospheric emissions of greenhouse gases (GHG) such as methane, carbon dioxide and nitrous oxide as well as other atmospheric pollutants like ammonia (Popeseu *et al.* 2011). To establish regular effective regulatory measures for emission from animal husbandry practices, current emission need to be quantified and studied. Emission of gases from livestock buildings is a major source of pollution within agricultural sector. Dairy cows and swine production highly depend on the barn microclimate (Herbut and Angrecka 2014). The micro-environment is affected to a considerable extent by the meteorological factors of the external environment, the type of construction of animal house, the management practices and the animals housed in time (Sundaram *et al.* 2009). In view of the above factors, the present study was carried out to assess the gaseous pollutants inside livestock sheds to generate a base line data.

MATERIALS AND METHODS

Experimental location: The experiment was carried out

Present address: ¹Research Scholar (nandhi7121989@gmail.com), ²Professor (natakumar@yahoo.com), ⁴Professor (drsundha22@yahoo.co.in), ⁵Professor and Head (thangathamil@gmail.com), Department of Livestock Production Management, Madras Veterinary College, Chennai. ³Associate Professor (b.samuel@tanuvas.org.in), Vaccine Research Centre - Bacterial Vaccines, Centre for Animal Health Studies.

at Tamil Nadu Veterinary and Animal Sciences University (TANUVAS), University Research Farm, located between latitudes 12°9' and 13°9' N and longitudes 80°12' and 80°19' E with an altitude of 22 m above MSL. The dairy shed which housed crossbred dairy cows, farrowing pen with 4 farrowing crates and pig fattener sty housing pigs from weaning till market age were selected as the experimental sheds. The long axis of the buildings was located in east-west orientation. A conventional dairy shed housing 14 crossbred cows with head to head system was selected. The dairy cows were provided with a floor space of 6 m²/animal. Pig sty with four pens having conventional open run and pen system housing 10–13 piglets from the age of weaning till market age, providing a floor space of 0.9 m²/pig were selected. Four conventional farrowing pens which housed one sow and 10–15 piglets in each pen with a floor space of 9 m²/sow were selected. All the 3 types of animal house formed the study subject. The sides of the sheds were covered with half wall to a height of 1.2 m. The sheds were provided with gable roof with full monitor ventilators. Cement concrete flooring was provided in all the sheds with a gradient of 1 in 40 towards the dung channel. Open drainage channel was provided inside the sheds. The dung and left over feed were removed manually 4 times daily.

Recording of microclimate in livestock sheds: The daily maximum and minimum temperature (C°) was recorded with wall hung maximum and minimum thermometer. The relative humidity (%) was calculated with the help of wet

and dry bulb thermometer reading. The wind velocity (ft/m) was recorded with digital anemometer. The microclimatic parameters were recorded at 8:30 h and 15:00 h in all the 3 experimental livestock sheds.

Temperature humidity index (THI) was calculated as follows

$$\text{THI} = 0.72 (\text{Cbd} + \text{Cwd}) + 40.6$$

where, Cbd, dry bulb reading in celsius and Cwd, wet bulb reading in celsius.

Recording of gaseous pollutants in livestock sheds: Air sampling for gaseous pollutants inside the experimental sheds were detected thrice a week by using multi gas Monitor. The gas samples were collected inside the sheds at head level of the animal (60 cm above the floor level) using the probe of the instrument. The gas monitor was installed in the morning to read the gaseous emissions continuously till evening (Figs 1, 2). The collected data were transferred to computer for analysis. The data were recorded daily during 3 seasons, viz. rainy (August-December), winter (January-February) and summer (March-April) during the year 2014–15. The data were subjected to standard statistical procedures.



Figs 1–2. 1. Air sampling inside the dairy-shed using multi gas monitor. 2. Air sampling for gaseous pollutants inside the pig shed using multi gas monitor.

RESULTS AND DISCUSSION

Microclimatic parameters: In the present study, microclimatic profile of the livestock houses is provided in Tables 1–4. Maximum temperature (°C) ranged between 30.00±0.43 and 36.83±0.44 in all the livestock houses studied. Summer recorded the maximum indoor temperature in farrowing pen followed by dairy shed and pig fattener sty, which significantly differed ($P < 0.01$). The minimum temperature (°C) ranged between 25.67±0.48 and 26.83±0.30 in livestock sheds in different seasons which did not differ between seasons. The indoor relative humidity (%) at 8:30 h was maximum in farrowing pen during winter season and minimum in pig fattener sty during summer. At 15:00 h, it was minimum in dairy shed during summer and maximum in farrowing shed during winter. The ambient temperature and relative humidity inside the sheds varied accordingly to the seasons. It was noted that the ambient temperature and relative humidity exceeded the comfort zone in all the livestock sheds which indicated that suitable modifications must be made in existing shed to maximize

Table 1. Temperature in livestock sheds in different seasons

Season		Temperature (°C)		
		Dairy shed	Pig fattener sty	Farrowing pen
Rainy	Maximum	31.83±0.72	30.00±0.43	31.50±0.50
	Minimum	26.33±0.50	25.67±0.48	27.17±0.67
Winter	Maximum	30.58±0.56	31.08±0.67	31.00±0.30
	Minimum	26.00±0.30	25.08±0.40	26.00±0.35
Summer	Maximum	35.92±0.53	34.92±0.73	36.83±0.44
	Minimum	26.00±0.37	25.67±0.38	26.83±0.30

Table 2. Relative humidity in livestock sheds in different seasons

Season		Relative humidity (%)		
		Dairy shed	Pig fattener sty	Farrowing pen
Rainy	8:30 h	84.17±0.78	80.17±0.39	78.50±0.56
	15:00 h	76.50±1.10	76.42±0.47	77.17±0.58
Winter	8:30 h	79.00±0.91	84.75±0.37	86.67±0.36
	15:00 h	78.00±0.92	76.58±1.32	78.83±0.51
Summer	8:30 h	74.00±1.56	68.50±0.72	74.83±1.07
	15:00 h	61.67±1.08	62.25±0.93	64.50±1.10

Table 3. Air velocity in livestock sheds

Season		Air velocity (ft/m)		
		Dairy shed	Pig fattener sty	Farrowing pen
Rainy	8:30 h	69.08±10.78	81.80±14.14	70.73±7.78
	15:00 h	55.43±10.25	65.59±6.85	87.91±13.53
Winter	8:30 h	70.83±7.78	65.84±9.20	69.66±14.57
	15:00 h	76.36±7.77	77.22±6.65	92.89±14.24
Summer	8:30 h	46.20±9.68	61.13±7.05	78.25±12.60
	15:00 h	77.67±7.29	97.86±15.33	84.28±16.05

Table 4. Temperature humidity index in livestock sheds

Season		Temperature humidity index (THI)		
		Dairy shed	Pig fattener sty	Farrowing pen
Rainy	8:30 h	82.87±0.69	82.56±1.20	81.99±0.77
	15:00 h	85.22±0.65	82.95±0.77	83.57±0.72
Winter	8:30 h	80.21±0.64	82.80±0.57	81.83±0.70
	15:00 h	83.68±0.42	83.50±0.61	82.87±0.75
Summer	8:30 h	86.50±0.51	85.39±0.62	85.00±0.59
	15:00 h	83.23±0.69	81.81±0.60	83.50±0.52

thermal comfort of animals which in turn will augment the productivity of farm animals. The microclimate of livestock buildings is influenced by macroclimate of region, housing system, ventilation, stocking density, orientation, diurnal outer ambient temperature and type of roofing (Sundaram *et al.* 2009). Wind velocity (ft/m) inside the livestock sheds ranged between 46 and 81.80 (ft/m) at 8:30 h and 55.43 and 97.86 at 15:00 h in livestock sheds during different seasons. Statistical analysis showed nonsignificant difference between the treatment groups. The indoor wind velocity of livestock sheds in the present study was almost in the recommended comfort level of 40–196 ft/m. The temperature humidity index (THI) values are presented in Table 4. THI values in the present study were higher both in the morning and evening hours than the ideal value of 72 (Misra and Mandal 2010) in all the sheds during different seasons. The temperature ameliorative and/or humidity control are required in all existing livestock sheds to provide maximum comfort to the animals.

Gaseous pollutants: The fortnightly mean±SE of gaseous pollutants comprising of carbon dioxide, ammonia and methane inside animal houses in forenoon and afternoon are presented in Table 5.

The CO₂ level (volume %) ranged between 0.019±0.07 and 0.43±0.13 in forenoon in the sheds. It was minimum in farrowing pen and maximum in pig fattener sty in forenoon, but in afternoon, the emission reduced in all the sheds irrespective of seasons. The CO₂ is released through respiration of animals and by manure decomposition in animal house. The present values were lower than those that reported by Kassik *et al.* (2013), Ransbeeck *et al.* (2013) and Ulens *et al.* (2014) in dairy and pig housing. In the present study the indoor CO₂ level in the forenoons and afternoons were within the threshold limit value (TLV) of 5,000 ppm. The NH₃ level (ppm) ranged between 0.33±1.14 and 2.58±0.47 in the sheds studied. The statistical analysis revealed no difference in NH₃ emission (ppm) in forenoon and afternoon within a particular season. However, there

was significant reduction ($P<0.05$) in NH₃ level in sheds in afternoon hours in all the seasons. The excreta deposited in animal sheds resulted in significant gaseous emission. Ammonia emission induced by hydrolysis of urea present in urine depend on parameters such as air velocity over manure surface, rate of urea hydrolysis, pH of excreta and air temperature. The values reported in the present study were much lower than earlier reports in dairy and swine facilities (Ransbeeck *et al.* 2013, Herbut and Angrecka 2014). The ammonia levels were very much within the TLV of 20 ppm in all livestock sheds irrespective of seasons. The daily mean methane emission ranged between 0.00 and 0.03±0.03 in forenoons, and 0.23±0.14 and 1.80±0.25 in afternoons. The statistical analysis showed no difference in methane emission in forenoon between sheds in particular season, whereas significant difference ($P<0.01$) was observed between sheds and season in afternoon. Most of the CH₄ in animal house is reported to be produced by natural biological processes such as bacterial action in gut of cattle, marsh lands, garbage dumps, landfills and anaerobic decomposition of manure. Since it is lighter than air and insoluble in water, methane tends to accumulate in ceiling of livestock sheds. In the present study, methane level recorded in all the animal houses were within the TLV of 5%. This may be due to good ventilation and frequent removal of manure in the sheds. Fielder *et al.* (2011), Ransbeeck *et al.* (2013) and Ulens *et al.* (2014) have reported that methane emission was influenced by ventilation in the animal house and manure handling and disposal systems. In the present study, the methane level was higher in afternoon and positively correlated with indoor air temperature which corroborated with the findings of Sun *et al.* (2008).

ACKNOWLEDGEMENT

The author are thankful to the Professor and Head, University Research Farm, Tamil Nadu Veterinary and Animal Sciences University, Chennai for extending all facilities to carry out this work.

Table 5. The gaseous pollutants in livestock sheds in different seasons

Season		Gaseous pollutants					
		Dairy shed		Pig fattener sty		Farrowing pen	
		Forenoon	Afternoon	Forenoon	Afternoon	Forenoon	Afternoon
Rainy	CO ₂	0.29±0.23	0.22±0.16	0.18±0.14	0.02±0.01	0.13±0.05	0.02±0.01
	NH ₃	1.40±0.37	0.23±0.14	2.58±0.47	1.11±0.40	1.68±0.62	1.15±0.64
	CH ₄	0	0.23±0.14	0	0.34±0.21	0	0.67±0.18
Winter	CO ₂	0.37±0.17	0	0.04±0.01	0.01±0.00	0.019±0.07	0.02±0.01
	NH ₃	0.41±0.17	0.35±0.17	1.32±0.49	0.44±0.29	0.51±0.21	0.50±0.33
	CH ₄	0	0.98±0.15	0	0.85±0.14	0	0.95±0.15
Summer	CO ₂	0.14±0.11	0.05±0.04	0.43±0.13	0.06±0.03	0.35±0.18	0.01±0.01
	NH ₃	0.55±0.21	0.53±0.28	0.71±0.33	0.10±0.06	0.33±0.14	0.23±0.12
	CH ₄	0.03±0.03	0.31±0.10	0	1.21±0.09	0	1.80±0.25

REFERENCES

- Fiedler A M and Mueller H J. 2011. Emissions of ammonia and methane from a livestock building natural cross ventilation. *Meteorologische Zeitschrift* **20**(1): 59–65.
- Herbut P and Angrecka S. 2014. Ammonia concentrations in a free-stall dairy barn. *Annals of Animal Science* **14**(1): 153–66.
- Kaasik A and Maasikmets M. 2013. Concentrations of airborne particulate matter, ammonia and carbon dioxide in large scale uninsulated loose housing cowsheds in houses for cattle with slatted floor and solid floors. *Biosystems Engineering* **62**: 127–32.
- Misra A K and Mandal D K. 2010. Climate change and the Indian bovine. *Indian Dairyman* **62**(1): 80–89.
- Popescu S, Borda C and Diugan E A. 2011. Microbiological air quality in tie-stall dairy barns and some factors that influence it. *African Journal of Agricultural Research* **6**(32): 6726–34.
- Ransbeeck N V, Langenhove H V and Demeyer P. 2013. Indoor concentrations and emissions factors of particulate matter, ammonia and greenhouse gases for pig fattening facilities. *Biosystems Engineering* **116**(4): 518–28.
- Sun G, Guo H, Peterson J, Predicala B and Lague C. 2008. Diurnal odor, ammonia, hydrogen sulfide and carbon dioxide emission profiles of confined swine grower. *Journal of Air and Waste Management Association* **58**(11): 1434–48.
- Sundaram S M, Gnanaraj P T, Murugan M, Murallidharan Ra and Kumararaj R. 2009. Housing designs and its impact on microclimate of cattle sheds in Chennai city. *Journal of Veterinary and Animal Sciences* **40**: 29–34.
- Ulens T, Millet S, Ransbeeck N V, Weyenberg S V, Langenhove H V and Demeyer P. 2014. The effect of different pen cleaning techniques and housing systems on indoor concentrations of particulate matter, ammonia and greenhouse gases (CO₂, CH₄, N₂O). *Livestock Science* **159**: 123–32.