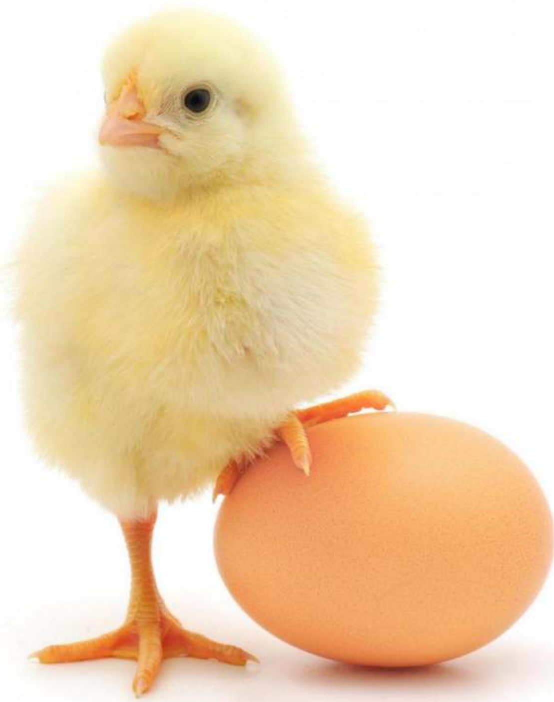
ISSN 1682-8356
ansinet.org/ijps



INTERNATIONAL JOURNAL OF POULTRY SCIENCE

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International Journal of Poultry Science 3 (6): 427-431, 2004

Concentrations of Aerial Pollutant Gases in Selected Poultry Pens in Imo State, Nigeria

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Abstract: Research on the concentrations of pollutant gasses in tropical livestock buildings is needed in order to establish baselines for exposure limits in the context of animal and human welfare in tropical environments. Concentrations of aerial ammonia NH_4, nitrous oxide (NO_2), flammable gas (methane, CH_4), carbon monoxide (CO), hydrogen sulfide (H_2S) and sulfur dioxide (SO_2) were measured in five intensive layer farms located Imo state during the month of August 2002. Data obtained were correlated with poultry house measurements in other to understand rates of increases of these pollutants as a result of changes in poultry house measurements. Overall mean aerial concentration of CO (3.11±0.73 ppm) was highest, followed by the 1.93 ± 0.14 ppm and 1.53 ± 0.71 ppm recorded for CH_4 and H_2S respectively, while the 0.09 ± 0.19 ppm and the 0.14 ± 0.20 recorded for SO_2 and NH_4 respectively were lowest. The range of 3.25 ± 0.7ppm to 4.0±0.0 ppm of CO obtained in the four pens FA, FB_1, FB_2 and FC was significantly ($P<0.05$) higher than those of the other pens. Similarly, the 8.3 ± 4.0 ppm H_2S obtained in FB_1 was significantly higher ($P<0.05$) than those of other pens. Predicted NO_2 gave the highest coefficient of determination (R^2) of 0.612, while predicted H_2S gave the least R^2 of 0.125. The correlation (R) between the concentration of aerial pollutants and poultry house dimensions ranged from 0.354 for H_2S to 0.782 for NO_2 and were positive but non significant ($P<0.05$). This study demonstrates relatively high standard of air quality in the poultry pens indicating probably that the tropical open sided pens being used in the study area are well suited for poultry production during the rainy season month of August.

Key words: Poultry; pollutant gases, poultry house measurements, tropical, Nigeria

Introduction

The environment in the livestock pen is a combination of physical and biological factors which exist as a complex dynamic system of social interaction, husbandry system, light, temperature and the aerial environment (Sainsbury, 1992). Intensification of livestock production systems during the last decades has led to increases in aerial pollutant emissions (Curtis and Drummond, 1982; Feddes and Liesko, 1993). Aerial pollutants in livestock buildings include organic and inorganic dusts, pathogens and other microorganism as well as gases (Whyte, 1993; Carpenter, 1996; Wathes *et al*., 1997).

Most gaseous pollutants found in such environment originate from the breakdown of fecal matter thus, their concentrations will at least in part, depend on the ventilation efficiency and rate, as well as the stocking density and movements of the animals (Wathes *et al*., 1983; MAFF, 1987). Over 100 gaseous compounds are found in the air of livestock building in the temperate zone (Hartung, 1988), and include aerial ammonia, carbon monoxide, sulphur oxide, hydrogen sulfide, nitrous oxide and flammable gas (methane), among others. Most are simple odorants, which may give rise to complaints among neighbors, while some are green house gases. In this zone, concentrations of most of the gases are usually in the range of parts per million (ppm) or lower with the exception of carbon dioxide which may record concentration levels 5 to 10 times higher than the ambient (Wathes, 2001).

Aerial pollutants have economic and public health importance in livestock production. Their concentration levels and emission rates in livestock buildings when high eventually result in health problems among housed animals. Their public health importance is predicated on the diseases they may cause in livestock workers when their levels become high in the livestock pens. Most studies of noxious gases in livestock pens have focused upon ammonia probably because of its' toxicity and role in acid rain formation. However, intensive livestock production contributes to global emission of other important aerial pollutants such as volatile (VOC) and reactive organic compounds (ROC) that impact adversely upon the countryside and has contributed many defects on the ozone layer (Nahm, 2000).

The concentrations of aerial pollutants in livestock houses and emissions from them have been studied extensively in the developed economies and several comprehensive reviews have been published (Harry, 1978; O'Neil and Philips, 1992, Wathes *et al*., 1997). These reviews highlighted some detrimental effects of these aerial pollutants on human welfare and livestock at large. Such information is however lacking for most tropical farming environments. Tropical livestock buildings are usually open sided thus enhancing natural ventilation of pens since there are usually minimal differences in temperature range all year round. These tropical livestock houses are expected to provide livestock with an equable temperature with limited diurnal fluctuations. However, such natural ventilation and other interacting factors in the tropical farming environment may predispose animals to continued exposure to gaseous pollutants. For example, in the warm tropical environments of southern Nigeria, humidity of the air is high and air movement is usually slow. More so, because of differences in livestock buildings structural measurements in this region, variations are bound to occur in terms of concentrations and emission rates of aerial pollutants.

Research on the concentrations and emission rates of pollutant gasses in tropical livestock buildings is therefore needed in order to establish baselines for exposure limits in the context of animal and human welfare in tropical environments. This study reports recent field measurements of the concentrations of aerial ammonia, nitrous oxide, methane, carbon monoxide, hydrogen sulfide and sulfur dioxide in selected poultry farms in the Owerri area of Imo State during the month of August 2002 and their correlation with livestock building measurements and some husbandry parameters.

Materials and Methods

Study area: Imo state is situated in the southern rain forest vegetational belt of Nigeria. It lies between latitude 5^0 and 6^0 3'N and longitude 6^0 15' and 7^0 34' E. The area is dominated by plains 200m above sea level except for elevations associated with the Okigwe uplands (Ofomata, 1975). It has an annual rainfall of about 1700mm to 2500mm, which is concentrated almost entirely between March and October. Average relative humidity is about 80% with up to 90% occurring during the rainy season. The mean daily maximum air temperature range from 28 to 35°C while the mean daily minimum range from 19 to 24°C.

In this rainforest zone, smallholder livestock production predominate with over 80% of rural families keeping west African Dwarf (WAD) ruminants and mixed breeds of local and exotic chicken (Molokwu, 1982; Ejiogu, 1990) primarily as source of investment, manure and meat at home or during festivals. In most parts of the state livestock are allowed to roam throughout the seasons, with little supplementation from kitchen wastes (Okoli *et al*., 2003). Prophylactic management of common infectious diseases is rarely practiced.

Pollutant gases poultry house measurements: Measurements of the concentrations of aerial ammonia NH_4, nitrous oxide (NO_2), Flammable gas (methane CH_4), carbon monoxide (CO), hydrogen sulfide (H_2S) and sulfur dioxide (SO_2) were made in five intensive layer farms located in the Owerri area of Imo state during the month of August 2002. Average number of birds per poultry pen was 2500 birds. The measurements were taken between 10th and 20th August 2002 and during morning (9-11am.) and afternoon (1-3pm) hours. Each house was monitored once over a period of 12 hours. The procedure described by Wathes *et al*. (1997), which involves taking representative readings at different locations in a pen was adopted. The factors considered included proximity to the open sided wall or middle of the pen as well as the sampling height. Such representative readings from each pen were later pooled to obtain the mean for each pen.

Concentrations of gases were measured in parts per million (ppm) as well as lower emissible limit (LEL) in the case of flammable gas (Methane) using the Gasman hand held personal gas detector (Crowcon, Instruments Ltd. England) that employs a catalytic bead sensor for flammable gas and electrochemical sensors for other gas measurements. During the gas measurements, these hand held equipment were held at about one foot above the litter level and the readings were recorded within 10 seconds. All analyses were calibrated for zero and span before and after reading.

In each farm, both inside and outside air temperature of the pens and relative humidity were also recorded. The length, width and height (floor to ridge) as well as the height of the side- walls of the pens were measured in feet. The husbandry system practiced in these farms (deep litter or battery cage) and the type of poultry kept, breed and age of birds were equally recorded.

Data analysis: Data generated were subjected to statistical analysis such as simple averages and analysis of variance (ANOVA). Where significant differences were observed, means were separated using the Duncan's multiple range test method, (Steel and Torrie, 1980). Furthermore, multiple regression statistics was used to determine the possible influence of building measurements on concentration of the gases.

Results

General observation: All the five farms studied were involved in commercial table egg production with layer flocks of different ages and breeds being reared intensively on deep litter (Table 1). Only one pen had birds in battery cages. Flock size in the different pens

Table 1: Husbandry methods employed in the various layer farms studied in Imo state during the month of August, 2002.

Pens	Litter	Age of litter	Type of bird	Age of bird	Flock size	Roofing method	Ambient temp (^{0}c)	Relative Humidity (%)
FA	D.L	12 Wks	L.H	56 Wks	2000	Iron Sheets	26.4	88.0
FB1	D.L	8 Wks	P., L.H	11 Wks	1500	Iron Sheets	26.5	88.0
FB2	D.L	8 Wks	L.H	36 Wks	2000	Iron Sheets	26.5	87.5
FC	D.L	3 Wks	BR,TR	122 Wks	1200	Iron Sheets	26.6	86.8
FD1	D.L	8 Wks	L.H	20 Wks	2500	Asbestos Sheets	26.5	88.0
FD2	B.C	1 day	L.H	112 Wks	2000	Asbestos Sheets	26.35	88.5
FD3	D.L	8 Wks	L.H	36 Wks	2500	Asbestos Sheets	26.35	88.9

F = Poultry pen, D.L = Deep litter, B.C = Battery Cage, L.H = Laying hens, P = Pullets, BR = Broilers, TR – Turkeys, WKS = Weeks.

Table 2: Concentrations of aerial pollutant gases in selected poultry pens in Imo state during the month of August 2002

PENS	FM (LEL)	NH_3 (PPM)	CO (PPM)	SO_2 (PPM)	H_2S (PPM)	NO_2 (PPM)
FA	2.0±0.0	0.0±0.0	3.25±0.7^a	0.1±0.0	0.1±0.0^b	0.1±0.0
FB_1	2.0±0.0	0.5±1.0	3.5±1.0^a	0.05±0.3	8.3±4.0^a	0.2±0.0
FB_2	2.0±0.0	0.0±0.0	4.0±0.0^a	0.0±0.0	2.0±0.0^b	0.15±0.3
FC	2.0±0.0	0.5±1.0	4.0±0.0^a	0.5±1.0	0.05±0.3^b	0.1±0.0
FD_1	2.0±0.0	0.0±0.0	2.5±1.0^b	0.0±0.0	0.15±0.3^b	0.15±0.3
FD_2	2.0±0.0	0.0±0.0	2.5±1.0^b	0.0±0.0	0.0±0.0	0.1±0.0
FD_3	1.5±1.0	0.0±0.0	2.0±1.4^b	0.0±0.0	0.1±0.4^b	0.15±0.3
TOTAL	13.5	1.0	21.75	0.65	10.7	0.95
Mean	1.93±0.14	0.14±0.20	3.11±0.73	0.09±0.19	1.53±0.71	0.14±0.13

ab means in the same column with different superscript are significantly different (P< 0.05).

studied ranged from 1500 to 2500 birds. Age of litter also ranged from 3 to 12 weeks. Mean daily air temperature during the period of study was 26.35^{0}C while mean relative humidity was 88%. In all the farms, making use of deep litter system, nests were provided at the end corners of the pens. Roofing materials utilized were mainly corrugated iron and asbestos sheets.

Aerial pollutant gases concentrations: Tables 2 shows the concentrations of aerial pollutant gases in the poultry pens during the month of August 2002. Overall mean aerial concentration of carbon monoxide (3.11±0.73 ppm) was highest followed by the 1.93 ± 0.14 ppm and 1.53 ± 0.71 ppm recorded for flammable gas (methane) and hydrogen sulfide respectively while the 0.09 ± 0.19 ppm and the 0.14 ± 0.20 recorded for SO_2 and ammonia respectively were lowest.

The range of 3.25 ± 0.7ppm to 4.0±0.0 ppm of CO obtained in FA, FB_1, FB_2 and FC were significantly higher ($P<0.05$) than those of the other pens. Similarly, the 8.3± 4.0ppm H_2S obtained in FB_1 was significantly higher ($P<0.05$) than those of other pens.

Table 3 shows the structural measurements of poultry houses used for aerial pollutants gases measurements. The mean values obtained were 98.57ft, 11.57ft, 34 ft and 1.57ft for the length, height, width and sidewall respectively. The highest value recorded in length was 218ft obtained from FD_2 while the lowest value was 63ft obtained from FB_2. The highest value recorded in height was 15ft while the lowest values was 6 ft and were obtained from FD_2 and FA respectively. The highest width value recorded was 47 feet obtained from FD_1 and FD_3 while the sidewall measurement recorded 2 feet as the highest value and 1 foot as the lowest measurement.

Correlation aerial pollutants concentrations and poultry house dimensions: The multiple linear regression equations to predict aerial pollutants concentrations from the various poultry house dimensions are shown in Table 4. Predicted NO_2 gave the highest coefficient of determination (R^2) of 0.612, while predicted H_2S gave the least R^2 of 0.125. The correlation (R) between the concentration of aerial pollutants and poultry house dimensions ranged from 0.354 for H_2S to 0.782 for NO_2 and were positive but non significant ($P<0.05$).

Discussion

Temperatures in the pens during the period of measurements were within the optimal range of 26 - 27^{0}C, while the mean humidity of 88.0% was much higher than the desirable 60-70% (Ferguson, 1986). This very high relative humidity is attributed to the period of the year (August), which is usually a heavy rainfall period. High temperature and humidity causes wet litter, which enhances the growth and multiplication of fungal, protozoa and bacterial pathogens in the tropics (Oluyemi

Table 3: Structural measurements of poultry pens used for aerial pollutants gases measurements in Imo state during the month of August 2002

Pens	Length (FT)	Height (FT)	Width (FT)	Sidewall (FT)
FA	94.00	6.00	27.00	1.00
FB_1	90.00	12.00	43.00	1.00
FB_2	53.00	13.00	32.00	2.00
FC	69.00	7.00	17.00	1.00
FD_1	78.00	14.00	47.00	2.00
FD_2	218.00	15.00	25.00	2.00
FD_3	78.00	14.00	47.00	2.00
MEAN	98.57	11.57	34	1.57

.

Table 4: Multiple linear regression relating poultry house dimensions to concentrations of aerial pollutants

Aerial pollutants	Prediction equation	Coefficient of determination (R^2) NS	Coefficient of correlation (R)	SE
FM	FM=2.315 - 0.002H - 0.012W	0.234	0.484	0.236
CO	CO=4.814 - 0.081H - 0.023W	0.400	0.632	0.748
H_2S	H_2S=0.174 - 0.131H+0.109W	0.125	0.354	3.517
NO_2	NO_2=0.053 - 0.327H+0.003W	0.612	0.782	0.029

FM = Flammable Methane, CO = Carbon monoxide, H_2S = Hydrogen sulfide, NO_2 = Nitrous oxide, W = Poultry house width, H = Poetry house height, SE = Standard error, NS = Not significant ($P<0.05$).

and Roberts, 1979).

The present results revealed that the concentrations of the various aerial pollutant gasses in the poultry pens were relatively low during the month of August. For example, the mean concentrations of ammonia in this study ranged from 0 to 0.5ppm. These figures are much lower than the current exposure limits of 20ppm recommended for animal welfare in Europe or the averages of 12.3ppm and 24.2ppm obtained in layer and broiler houses in the UK during winter and summer month (CIDR, 1992; Wathes *et al.*, 1997). It would seen from this study that the relatively clement weather conditions associated with mild temperatures and increased air movement during this period of the year may have helped in moving gases generated inside the poultry pens to the outside. Taken together, these measurements demonstrate relatively high standard of air quality in the poultry pens. It would seem from the limited results obtained that the tropical open sided pens being used in the study area are well suited for poultry production during the month of August.

Although a single measurement of 16.50ppm of H_2S recorded at the middle of FB_1 harboring 11 weeks old pullets kept on an 8 weeks old litter was also recorded, the reason for this relatively high concentration is not understood and requires further investigation.

Because of the low levels of gases obtained in the various house measurements during the period of study, there is the need to extend the study to other periods of the year especially the dry season months in other to further elucidate the effects of inclement whether on gas concentrations.

The study revealed that there is lack of standardization in the construction of poultry pens in the study area. Some of the houses were either too wide or too low. The optimal width of poultry pens in the humid tropics has been shown by to be 10m wide with 1.2m internal passages. These help for more effective ventilation and reduction of heat irradiation from the roof especially during the hot periods of the year. Similarly, the sidewall measurements recorded in the poultry pens were below standard levels, which are usually three coaches of blocks (3ft) for growers, broilers and layers in the humid tropics (Izunobi, 2002).

The study equally revealed the relative contribution of poultry house dimension to the concentration of aerial pollutants and tried to explain the rate of increases of these pollutants due to changes in house measurements. While NO_2 and CO concentrations and house dimensions were highly related (78.2 and 63.2% of the time respectively), CH_4 and H_2S were lowly correlated with house measurements (48.4 and 35.4% of the times respectively). These results specifically indicate that increasing the height or reducing the width of the pen will result in relative lowering of the concentrations of pollutant gases.

Conclusion : Even though this study returned low levels of gases for the area during the month of August, there is the need to extend the study to other periods of the year especially the dry season months in other to further elucidate the effects of inclement whether on gas concentrations.

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