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In situ measurement of ammonia and greenhouse gas emissions from broiler houses in France

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Abstract

An experimental technique was developed for measuring gaseous emissions including ammonia (NH_3), nitrous oxide (N_2O) and methane (CH_4) from broiler houses. This technique included the monitoring of the air flow rate and the gaseous concentrations. NH_3 was determined using acid trap while N_2O and CH_4 were determined continuously by infrared gas analyser and sequentially by gas chromatography. Moreover, N_2O and CH_4 emissions were monitored above the litter using closed flux chambers at the end of the experiment. No emissions of N_2O and CH_4 were observed neither during the growth of the broiler nor above the litter at the end of the experiment. Ammonia concentration varied between 0.8 and 32 ppm in the building. Total ammonia emissions were estimated to 5.74 gN animal^{-1} during this experiment. According to this result, ammonia emissions from broiler houses could be estimated to 5.3 kt of N per year in France.

Keywords: Ammonia; Greenhouse gas; Broilers; Litter; Broiler houses; Gaseous emissions

1. Introduction

International negotiations on mitigation of greenhouse gas (GHG) emissions (UNFCCC, 1997) and ammonia emissions (UN/ECE, 1999) are being discussed by Countries able to present an inventory based on reliable values for emissions from sources on their territory. Among the different sources, agriculture and livestock production represent a major source of emission of both pollutants, i.e. 40% for methane and nitrous oxide and 90% for ammonia (Morard, 2000). Total gaseous emissions in France from agriculture were estimated to be 633 kt of N for ammonia (NH_3), 121 kt of N for nitrous oxide (N_2O) and 1259 kt of C for methane (CH_4), (Fontelle et al., 2002). These estimations were calculated using the CORINAIR methodology (European Environment Agency, 1999) based on emission factors proposed by European Agency of Environment.

A proportion of these emissions occurs in the livestock building (pig, cattle and poultry mainly) and escape to the environment with the ventilation air. Concerning the broilers building, the emission factor for ammonia emissions used by this method is about 19 gN animal^{-1} which leads to emissions equivalent to 17.6 kt of N per year in France, considering a total production of 928 million of animals. This emission factor is close to that observed by Elwinger and Svensson (1996) and Wathes et al. (1997) but higher than that observed by Demmers et al. (1999) and Groot Koerkamp and Ueng (1997).

In this context, the main purpose of this study was to collect data on gaseous emissions, especially GHG and ammonia, from broiler houses with typical building design (material of floors and litter characteristics and quantity) used in France.

2. Methods

2.1. Building description

An experiment was made on an experimental poultry station of the French Agency for Sanitary Security of Food (AFSSA) at Ploufragan in North Brittany

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(France). The broiler building was divided into two separated rearing rooms of 240 m^2 each equipped with different type of floors: clay and concrete. In both rooms, 5086 chickens were reared (21 animals m^{-2}). Water was supplied by nipple drinkers to avoid spillage and feeding was automatically controlled and recorded. Each room was equipped with four fans with theoretical flow rate of 3000, 6000, 12,000 and 12,000 $m^3 h^{-1}$, respectively. Ventilation rate was daily adjusted according to inside atmospheric parameters (temperature, humidity, ...), animal's growth, age; this was achieved by combining the number of fans running and the time for which each ran during the day. Wood shaving litter was added in each room at different levels; 1 and 5 kg m^{-2} for concrete and clay floors, respectively. Temperature was controlled by means of gas fuelled heaters and ventilation rate in order to decrease from 32 °C on the first day, to 27 °C after 2 weeks, 23 °C at the 4th week and finally to 18 °C during the end of the raising period.

2.2. Description of the experiment

The experiment was conducted during January–February 2000. During the rearing period, the working of the fans in the room with concrete floor was monitored using probes. The ventilation flow rate of each fans was previously measured according to Log-tchebycheff method (ASHRAE, 1992). Both results allowed us to determined the air flow rate. Gaseous concentrations including NH_3, N_2O and CH_4 were determined in the room with concrete floor during the raising period. Outlet air from the broiler concrete room was continuously pumped (10 l min^{-1}) and sampled. Air was continuously analysed for N_2O and CH_4 concentrations using an infrared gas analyser and recorded when the fans were running. Moreover, air samples were manually taken every 3–5 days for 1–2 h and analysed for N_2O and CH_4 using a gas chromatograph (GC) equipped with an electron capture detector (ECD) for N_2O analysis and a flame ionization detector (FID) for CH_4 analysis. The GC was supplied with a compatible ECD di-nitrogen (N_2) carrier gas and was calibrated using CH_4/N_2O standards. When the fans were running, a known volume (about 5 l min^{-1}) of the sampled air bubbled through a sulphuric acid solution (0.1 N) to trap NH_3. The amount of NH_3 in the acid trap solution was determined in the laboratory using steam distillation. The acid trap was collected and replaced every 2–3 days. These results allowed us to calculate the mean concentration of NH_3 over the 2–3 days period by dividing the amount of NH_3 by the air volume passed through the acid trap during the same period. Concurrently, knowing the air flow rate in the building, these results allowed us to calculate the total NH_3 emissions from the building. No experimental data for gaseous concentrations were obtained from the day 17 to the day 24 due to a frozen period. In fact, the outdoor temperature was lower than 0 °C and some ice was formed in the air sampling tube stopping the air sampling from the building. Average concentrations between the day before and after this period were taken into account for further calculations.

At the end of the rearing period, N_2O and CH_4 emissions above the litter were measured in both rooms using closed flux chambers (volume 0.0102 m^3). Six chambers were placed in each room and gas was accumulated for 30 min. Samples were taken every 10 min. and analysed for N_2O and CH_4 by the GC previously described.

The number of birds and the total weight of the birds in each room were measured at the end of the experiments. The litter was sampled in both rooms taking into account the spatial variation of the composition due to the location and the number of drinking and eating elements (Aubert and Guiziou, 1997). Dry matter and ashes were determined after drying the fresh matter at 105 °C for 48 h and after burning the dry matter at 550 °C for 5 h, respectively. Total ammonium nitrogen (TAN) was determined by steam distillation of the fresh samples whereas total Kjeldhal nitrogen (TKN) was previously digested using the Kjeldhal procedure.

3. Results and discussion

3.1. Technical performances

Each rearing room was filled with 5086 chickens of about 40 g each. Chickens were removed after only 35 days and the mean weight of the birds were 1.806 and 1.886 kg $animal^{-1}$ for the concrete and the clay floor rooms, respectively (Table 1). During the growing period, about 3.75% of the birds died and consequently,

Table 1
Technical performances

Room	Numbers of broilers at the start	Feed intake (g $bird^{-1}$)	Average weight at the end (g $bird^{-1}$)	Dead broiler (%)	Feed conversion ratio	Water/feed ratio	Total live weight at the end (kg)
Concrete floor	5086	3095	1806	3.81	1.71	1.75	8835
Clay floor	5086	3092	1886	3.68	1.71	1.68	8850