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Emission factors of greenhouse gases from layer and broiler barns in Cameroon

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ABSTRACT

Limited information is available in the literature on greenhouse gas (GHG) quantification from livestock production systems in Africa. Therefore, this project was carried out to generate baseline emission factors of methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2) from broiler and layer barns with building design typical of Cameroon. Emissions were measured from two broiler barns during the entire production cycles and a layer barn for a limited period using flux chambers. Methane emission factors from the broiler barns with mud and cement floors were 0.96 ± 1.04 and 0.36 ± 0.17 mg bird^{-1} hr^{-1} respectively, and 0.76 ± 0.56 mg bird^{-1} hr^{-1} from the layer barn with cement floor. Nitrous oxide emission from the broiler barns with mud and cement floors were 12.94 ± 10.11 and 1.68 ± 1.02 mg bird^{-1} hr^{-1} respectively, and 0.21 ± 0.28 mg bird^{-1} hr^{-1} from the layer barn. Carbon dioxide emission factors from the broiler barns with mud and cement floors were 9327 ± 3508 and 25526 ± 6904 mg bird^{-1} hr^{-1} respectively, and 8942 ± 36756 mg bird^{-1} hr^{-1} from the layer barn. When scaled per livestock unit (LU), where 1 LU is 500 kg bird weight, CH_4 emissions were 0.16 ± 0.17 and 0.06 ± 0.03 g LU^{-1} hr^{-1} from the broiler barns, and 0.19 ± 0.14 g LU^{-1} hr^{-1} from the layer barn. Nitrous oxide emissions were 2.16 ± 1.69 and 0.28 ± 0.17 g LU^{-1} hr^{-1} from the broiler barns, and 0.05 ± 0.07 g LU^{-1} hr^{-1} from the layer barn. Broilers reared in management systems with wood shavings on mud floor had relatively high CH_4 and N_2O emissions compared to broilers on wood shavings and cement floor, with the contrary observed for CO_2. The emissions N_2O were significantly higher from broiler barns compared to layer barns. Emissions were higher in the mornings compared to later periods of the day. Given the observed results, GHG emission mitigation strategies need to be customised for each building design and management system.

1. Introduction

Increased concentrations of greenhouse gases (GHGs) such as methane (CH_4) and nitrous oxide (N_2O) are of environmental concern because of their implications on the global climate (Aneja et al., 2001; IPCC, 2001, 2013). Livestock production is an important source of GHG emissions into the atmosphere, with manure management and enteric fermentation accounting for 35–40% of the total anthropogenic CH_4 emissions and about 80% of CH_4 emitted from agriculture (FAO, 2006). Livestock activities also contribute 65% of the global anthropogenic N_2O emissions, and about 75–80% of the emissions from agriculture (FAO, 2006). As such, up to date data of emission factors from the main livestock production categories is needed for inventory purposes and to validate mitigation strategies.

There is a growing demand for livestock produce in African countries, which is leading to intensification of livestock production, especially poultry production systems (UNSIC, 2014). This expansion and intensification is likely to cause changes in the trend of GHG emissions. Despite these changes in livestock production, there is very limited information available in the literature on GHG emission rates from production systems in Africa and hardly any such data in Cameroon, where poultry houses are typically naturally ventilated with litter comprised of wood shavings. It has been projected that the developing world contributes 75% of global GHG emissions from ruminants and 56% of emissions from monogastrics (Herrero et al., 2013). Emissions of GHGs have mostly been quantified from poultry housing systems for climatic conditions that are typical of Europe and North America (Demmers et al., 1999; Guiziou and Beline, 2005; Fabbri et al., 2007). Africa emission factors of GHGs cannot be deduced directly from either Europe or North America studies due to differences in housing

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design, management systems and climatic conditions.

Most emissions from poultry originate from manure management as opposed to ruminants where enteric emissions are equally important, with estimates suggesting that enteric fermentation accounts for about 80 and 30% of CH_4 in dairy cow and pig production respectively (Monteny et al., 2001). Methane production from manure proceeds through hydrolysis of hemicellulose and cellulose, acidogenesis, acetogenesis and finally methanogenesis (Monteny et al., 2006), with production rates determined by temperature and storage time (Alvarez et al., 2006; Chae et al., 2008). The use of wood shavings as bedding material increase the dry matter (DM) content and the carbon-to-nitrogen (C/N) ratio of the manure, which may reduce ammonia (NH_3) emissions, but rather increase N_2O or CH_4 emissions (Monteny et al., 2006). As such emission measurements from poultry should focus on the floor and manure.

Accurate country specific GHG reporting under the Paris Climate Agreement is essential for applying reliable GHG mitigation strategies. As such this project was carried out with the aim of deriving baseline data for CH_4 and N_2O, alongside carbon dioxide (CO_2) emission factors from broiler and layer houses with building design typical of Cameroon.

2. Materials and methods

2.1. Site description and technical performance

Measurements of GHG emission factors were carried out in two broiler barns and in a layer barn with housing designs and production systems typical of Cameroon.

2.1.1. Bwanda broiler barn

The Bwanda broiler barn is found in Bwanda, located in the Buea neighbourhood – the regional headquarters of the South West Region, Cameroon. The farm was made up of two buildings; one of which had an office space, a storage room and a brooding room. The second building was used as a broiler fattening barn. The broiler barn with dimension 65 × 15.5 m was divided into twenty rooms (~6.65 × 6.35 m each), a main entrance and a 1.7 m wide alleyway. The length of the barn was made of plywood up to a height of 0.6 m from the ground, and the remaining top part covered with wire mesh to enhance ventilation. The width of the barn was completely covered with plywood. The barn had a couple roof with two-sided ridge ventilation (Fig. 1). It had a mud floor covered with wood shavings as bedding material. The floor was completely cleaned and the barn disinfected between fattening cycles. The floor was completely covered with wood shavings at the start of the fattening period, and a fresh layer added after every 10 days. Manure removal was at the end of the fattening period. Due to some unexpected difficulties faced by farm management, the birds lasted 4 weeks in the brooding room rather than the usual 2 week period. They were moved into the fattening barn and distributed into four of the twenty rooms. The birds were progressively feed with the starter composed of 400 kg concentrate and 550 kg corn flour, the grower composed of 300 kg concentrate and 1000 kg corn flour, and the finisher composed of 200 kg concentrate and 1000 kg corn flour. Feed was supplied twice a day at 10 a.m. and 3:30 p.m. in rectangular wooden feeders. Water was consumed ad-libitum and was supplied using several automated and stationary drinkers. The birds were administered vaccine every 7 days through drinking water. A summary of the technical performance of the broilers was measured and presented in Table 1.

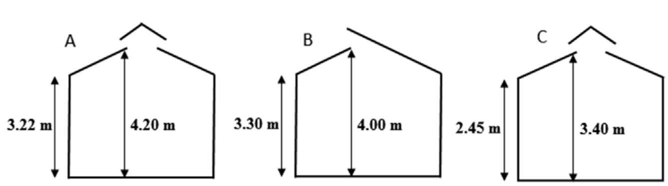

Fig. 1. Schematic of the Bwanda broiler barn (A), Bomaka broiler barn (B) and Nkwen layer barn (C).

2.1.2. Bomaka broiler barn

The Bomaka barn is found in Bomaka, also located in the Buea neighbourhood. Detailed production information is presented in Table 1. The farm had two buildings; one building had an office and a storage room while the other building was the broiler barn. The length of the barn was made of plywood to a height of 0.60 m from the ground with the remaining top part covered with a plastic mesh to ease ventilation. The width of the barn was completely covered with plywood. The barn had a couple roof with one-sided ridge ventilation (Fig. 1). The broiler barn with a dimension of 55 × 11.22 m, was divided into two equal rooms (27.50 × 11.22 m each). Both rooms were used for brooding and progressively extended for fattening the broilers. During the first two weeks, a small section of each room was enclosed with cardboard paper and heated with a charcoal heater for brooding. During the brooding period, the plastic mesh in the side walls were covered with polythene papers to conserve heat. After two weeks the cardboard paper and polythene linings were removed and the room used for fattening. The barn had a cement floor covered with wood shavings as bedding material. Manure management was similar to that in the Bwanda barn. Feed ration was similar to that in the Bwanda farm. The birds were fed manually at about 9 a.m. and 5 p.m. daily using rectangular wooden feeders. Water was supplied manually through stationary drinkers.

2.1.3. Nkwen layer farm

The Nkwen layer farm is found in Nkwen, located in the Bamenda neighbourhood – the regional headquarters of the North West Region. Detailed production information is presented in Table 1. The farm had two layer barns with dimension 40 × 12 m per barn. Each barn was partitioned into five rooms. On average, one of the barns had 3000 layers which were 19 months while the other barn had 5000 layers which were 6 months old (Table 1), evenly distributed in the rooms. Both long walls of the barn containing the older layers were constructed using mud blocks to a height of 0.8 m from the ground, while the upper section was made of bamboo to a height of 1.6 m. The long walls of the barn containing the younger birds was constructed using wood to a height of 0.8 m from the ground, while the upper section was made of wire mesh. The side walls of both barns were covered with mud blocks up to the ridge. The birds were fed twice a day with feed consumption data presented on Table 1. The feed was composed of corn, broken rice and concentrate. Eggs were collected twice a day (~9 a.m., 12 p.m. and 3 p.m.). The barn had a cement floor with wood shavings brought from the brooding room and applied just once before the birds were brought into the layer barns. No additional wood shavings was used throughout the laying cycle. Manure was removed intermittently through the laying cycle based on demand from buyers. Water consumption was through automatic drinkers. Natural ventilation was through the side walls and ridge (Fig. 1). Artificial lighting was put off between 9 p.m. and 5 a.m.

2.2. Gas concentration measurement

Emission rates were quantified using the non-steady state flux chamber method, where the change in gas concentrations over time in the headspace is related to the flux (Sommer et al., 2004; Duran and Kucharik, 2013). Gas samples were collected using two flux chambers. Chamber locations in the barns were varied during the measurement periods to account for the spatial heterogeneity of the litter surface. Collars were inserted into the litter a day prior gas sample collection. Gas samples were collected twice a week during the fattening periods in the Bwanda and Bomaka broiler barns. Headspace air in each chamber was sampled twice a day; in the mornings (10:40, 10:50, 11:00) and in