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MEASURING AIR QUALITY IN BROILER BREEDER HOUSES IN GEORGIA

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ABSTRACT

Poultry and egg production is facing a number of grand challenges associated with environmental quality and animal health. For instance, poultry workers and animals are faced with the challenge of poor air quality in the poultry houses, especially in winter time when house ventilation is limited. Recently, most studies have been focused on broiler grow-out houses and layer houses, very limited works have been conducted in commercial broiler breeder's houses, where parent flocks produce hatching eggs for broiler chicks. The objectives of this study were to monitor the dust and ammonia levels in commercial broiler breeder houses and discuss potential influential factors. Two identical broiler-breeder houses were monitored in Southern Georgia. Results show that two houses had similar air temperature (70-82°F), relative humidity (40-80%), ammonia (8-12 ppm), and dust level (e.g., $PM_{2.5}$ was about 0.5-1 mg m^{-3}). Dust monitored at 1 ft above floor (bird level) was 50% higher than 3 ft above floor because bedding floor was the primary source of airborne dust and animals' movement led to the increase of dust levels.

INTRODUCTION

Poultry and eggs provide the most valuable protein for human beings and animals. Currently USA is the world's largest broiler chicken producer and 2nd largest egg producer. However, poultry and egg production is facing a number of challenges associated with environmental animal health, welfare, food safety, and environmental impacts (Ni et al., 2017a, 2017b). For instance, confined housing systems are sources of aerial pollutant emissions such as ammonia (NH_3) and particulate matter (PM) (Ritz et al., 2006; Hayes et al. 2013; Chai et al., 2017, 2018, 2019; Chai and Ritz, 2020). Poultry farm workers and animals are faced with the challenge of poor air quality in the houses, especially in winter time when house ventilation is limited. National or regional level measurements, e.g., National Air Emission Monitoring Study (NAEMS, 2007-2010) and the Coalition for a Sustainable Egg Supply project (CSES, 2011-2013), have been conducted to quantify NH_3 and PM emissions from poultry production systems (Chai et al., 2010, 2012, Li et al., 2013; Wang-Li et al., 2013; Ni et al., 2012, 2017a, 2017b; Zhao et al., 2015).

However, those national or regional studies didn't include the broiler breeder housing system, which houses broiler breeders, the parent flocks that produce fertilized eggs for hatching chicks of meat chickens (broilers). Breeders (i.e., hens and roosters at ratio 8-10 hens to 1 rooster) usually stay up to 65 weeks (wk) in confined poultry houses, where the environment and management can have a vital impact on their health and welfare. Dust and ammonia are two primary air quality indicators of concern in poultry houses as high levels of dust (together with carried airborne microorganism such as bacteria, pathogens, and viruses) and ammonia can cause respiratory system infections and other diseases in animals (Donham et al., 2002). Therefore, the objectives of this study were to monitor temporal and spatial air quality in a commercial broiler breeder houses and to discuss potential influential factors and mitigation strategies.

MATERIALS AND METHODS

The studies were conducted in two identical commercial size broiler breeder houses (Figure 1) in Georgia in Spring 2019 (March to April). Each house had 10,000 breeders (Ross; 35 weeks of old on March 1st, 2019). Each house measured 350 ft L * 140 ft W * 10 ft H. An optical PM sensor (DustTrak Drx Aerosol Monitor 8533, TSI Incorporated, Shoreview, MN) (Figure 2) was used to measure PM concentrations of different particle sizes, i.e., PM1, PM2.5, PM4, PM10 and total suspended particulate (TSP), in three different representative locations, i.e., 100 ft, 200 ft, and 300 ft in the middle of the width direction). Besides, PM levels at the heights of 1 ft, 2 ft, and 3 ft at different representative locations were monitored to assess vertical stratifications. The NH_3 concentrations were monitored with portable NH_3 sensor (GasAlert, BW Technologies Ltd., Arlington, TX) (Figure 3). Air temperature and relative humidity were monitored at 10 min time intervals continuously (HOBO MAX, Onset, Bourne, Mass) (Figure 4).

Figure 1. The broiler breeder house (350 ft L * 140 ft W * 10 ft H).

Figure 2. Dust monitoring in the house.

Figure 3. Portable ammonia sensor (GasAlert).

Figure 4. Temperature and relative humidity sensor (Hobo).

RESULTS AND DISCUSSION

Results show the air temperature (70-82°F), relative humidity (40-80%), ammonia (8-12 ppm), and dust levels (0.5-1 mg m^{-3} - $PM_{2.5}$ and 1-1.5 mg m^{-3}-PM_{10}, Figure 5) in the two houses. The dust level in two houses are comparable (e.g., p=0.093 for PM2.5 and p=0.152 for PM10 under *t* tests. Differences were considered significant at $p < 0.05$). The dust levels monitored at 1 ft (0.3m) above floor (bird height) were about 50% higher than 3.3 ft (1 m) above floor (Figures 5 and 6) because bedding floor was the primary source of airborne dust and animals' movement led to the increase of dust levels. This finding agrees well with the similar measurements conducted in a cage-free laying hen house (Figure 7). In addition, the dust level was lower at the place closer to the inlets in the length direction (Figure 8).

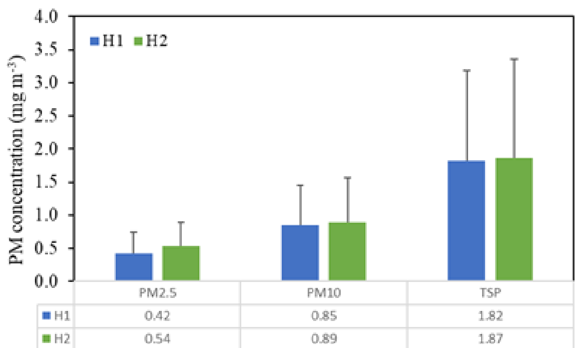

Figure 5. Dust levels in house 1 (H1) and house 2 (H2): PM2.5 and PM10 are particulate matter with size smaller than 2.5 and 10 micrometers in diameter, respectively. TSP means total suspended particles.

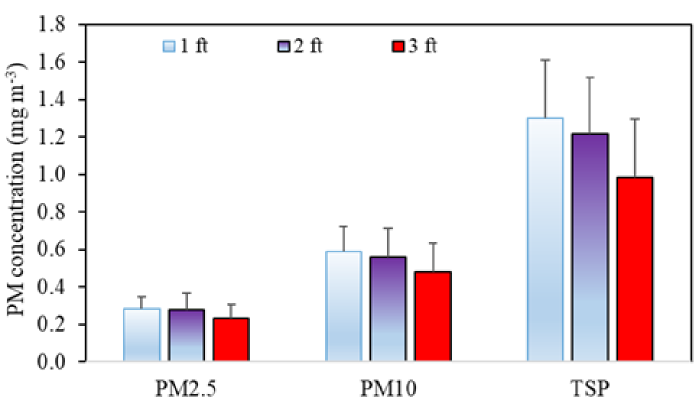

Figure 6. Dust levels at different height above litter floor.

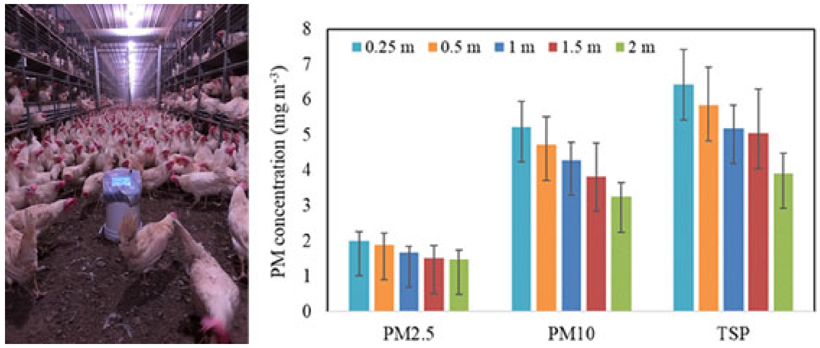

Figure 7. Dust measurement in a cage-free house: Vertical distributions of PM2.5, PM10, and TSP concentrations in cage-free hen house (mean ± SE of PM levels measured in four location) (0.25 m =0.8 ft, 0.5 m = 1.6 ft, 1 m = 3.3 ft , 1.5 m = 4.9 ft, and 2 m = 6.6 ft) (Chai et al., 2019).

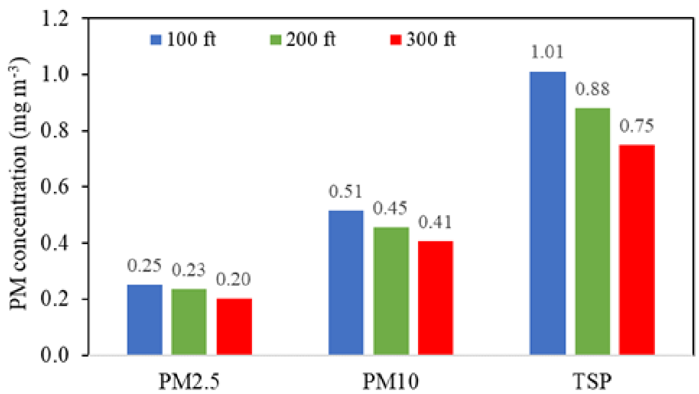

Figure 8. Dust levels in different locations of House 1. The 100 ft was closer to the exhaust tunnel fans and 300 ft was closer to the inlet.

Ammonia levels in breeder houses were lower than published results for broiler grow-out houses in Georgia (e.g., about 50 ppm) because grow-out houses have different structure and housing management (e.g., ventilation systems and animal density) as compared to breeder houses (Fairchild et al., 2006). Ammonia levels were monitored with a portable sensor (e.g., GasAlert), which had been previously tested with comparable reading to INNOVA 1412, an optical gas analyzer with high accuracy (Chai et al., 2010).

Researchers have shown that litter (bedding) is the primary source of NH_3, PM, and airborne organisms in poultry houses (Chai et al., 2018b, 2019; Johnson et al., 2021). Litter in poultry houses harbors a complex microbiome. High amount of chicken excreta combined with water dripping from nipple drinkers usually generates significant amount of NH_3, bacteria, and pathogens (Johnson et al., 2021). The current farm included wood chips in bedding that potentially reduced the moisture accumulation on the floor, which might assist moisture evaporation from the bedding and reduce the generation of ammonia from the litter. Further studies on the effect of bedding materials are guaranteed.

CONCLUSIONS

Two identical broiler-breeder houses (10,000 Ross breeders per house) were monitored in Georgia for exploring dust levels with the portable optical dust monitor. Results show that the dust level in two houses are comparable (i.e., 0.5-1 mg m^{-3} - $PM_{2.5}$ and 1-1.5 mg m^{-3}-PM_{10}). Dust monitored at 0.35 m above floor (bird level) was 50% higher than 1 m above floor because bedding floor was the primary source of airborne dust. The findings agree with the results we found in a cage-free laying hen house. Two houses had similar air temperature (21-28 °C), relative humidity (40-80%), and ammonia levels (8-12 ppm) during the test in Spring 2019. The current farm's inclusion of wood chips in bedding potentially reduced the moisture accumulation on the floor, which might assist moisture evaporation from beddings and reduce the generation of ammonia from litter. Further studies on the effect of bedding materials are guaranteed.

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