

# Investigation of Ammonia Concentration Variations in the Vicinity of a Large Commercial Chicken Layer Farm

Extended abstract # 10

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## INTRODUCTION

Health effects of particulate matter (PM) emitted from animal feeding operations (AFOs) are of increasing interest.<sup>1-5</sup> Currently, PM exposure estimates for most epidemiology studies and risk assessments are based upon the EPA's ambient air quality data,<sup>6</sup> of which over 90% is collected in urban areas. Lack of information about the linkage of AFO PM and public exposure may cause inaccuracies in studies of health effects or associated risk assessment.<sup>7</sup>

Ammonia (NH<sub>3</sub>), as a main constituent of air emissions from AFOs,<sup>8</sup> is a major precursor to atmospheric PM fine.<sup>9</sup> Investigation of the fate and transport of NH<sub>3</sub> emitted from AFOs will enhance our understanding of the formation of secondary PM in the vicinity of AFO facilities.

The reported research is part of a project that aims to establish basic understanding of the relationships between particular mass and associated characteristics including both PM<sub>2.5</sub> (PM fine) and PM<sub>10-2.5</sub> (PM coarse) emitted from AFO facilities and possible public exposure surrounding those facilities. This understanding will provide a basis for further study of health effects and risk assessment associated with AFO PM.

The objective of the reported research effort is to investigate NH<sub>3</sub> concentration variations in the vicinity of AFOs, so that the role of NH<sub>3</sub> in formation of secondary PM can be examined in future studies.

## EXPERIMENTAL METHODS

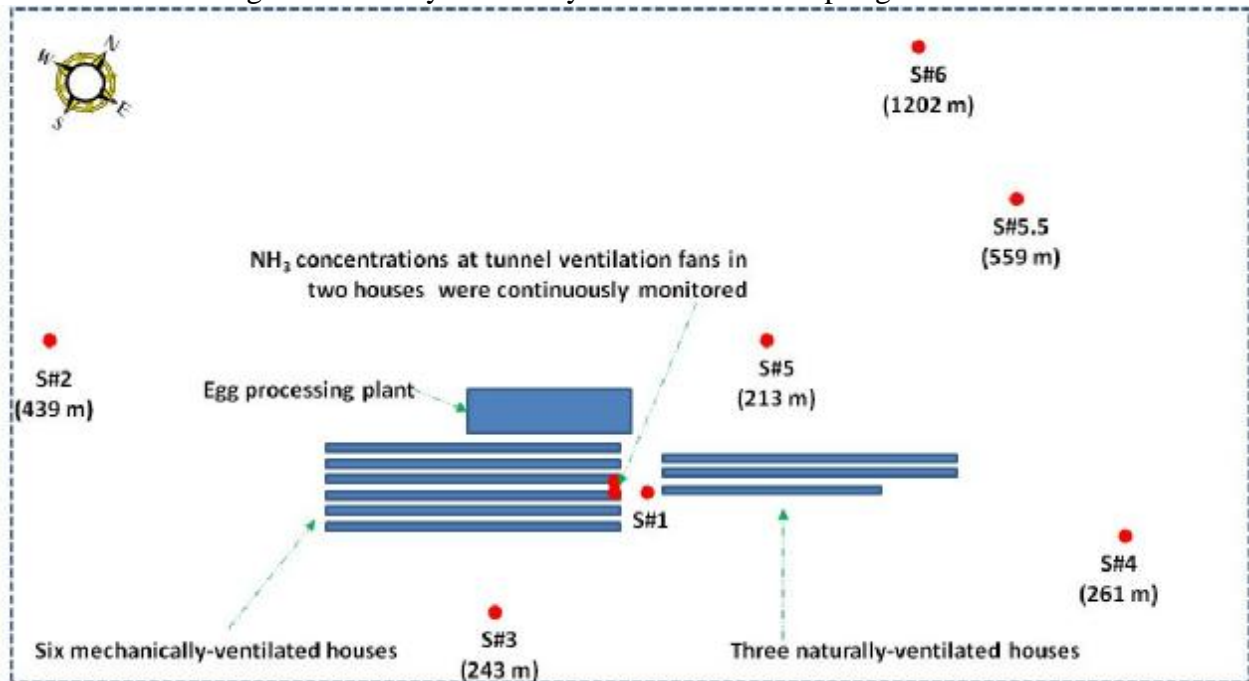
The experiments were conducted at a commercial layer farm with six mechanically-ventilated high rise houses, three shallow-pit naturally-ventilated houses and an egg processing plant. The farm is located in the northeast region of Raleigh, North Carolina. The average daytime high temperatures at the farm site range from 10°C in winter to 32 °C in the summer. Average overnight low temperatures range from -2 °C during winter to 20 °C in the summer. Prevailing winds are from the southwest year-round.

The layout of the farm and air sampling locations are illustrated in Figure 1. Each mechanically ventilated high rise house has dimensions of 175 m in length and 18 m in width and contains about 100,000 hens on the upper floor. Manure falls down into the first floor, where it is stored for up to one year. There are eight 122-cm diameter exhaust fans installed on the second floor and nine fans installed on the first floor of each end-wall of the houses.

The NH<sub>3</sub> concentrations at exhaust fans inside two houses have been continuously monitored since September, 2007 as part of the National Air Emission Monitoring Study (NAEMS).<sup>10</sup> Ammonia concentrations at representative upwind and downwind distances (from 213 to 1202

m, see Figure 1) from the buildings were investigated through the summer of 2008. Air samples were taken on weekly basis using Tedlar bags at seven sampling locations (S#1 – S#6) from June 16 through August, 2008. Ammonia concentrations of the bag samples were measured in 30 min after samples were taken using a photoacoustic multi-gas analyzer (INNOVA Model 1412, AirTech Instruments A/S, Denmark). In addition to NH<sub>3</sub> concentration data, the meteorological variables such as wind speed/direction and temperature on the farm were simultaneously monitored.

Figure 1: The layer farm layout and the air sampling locations.

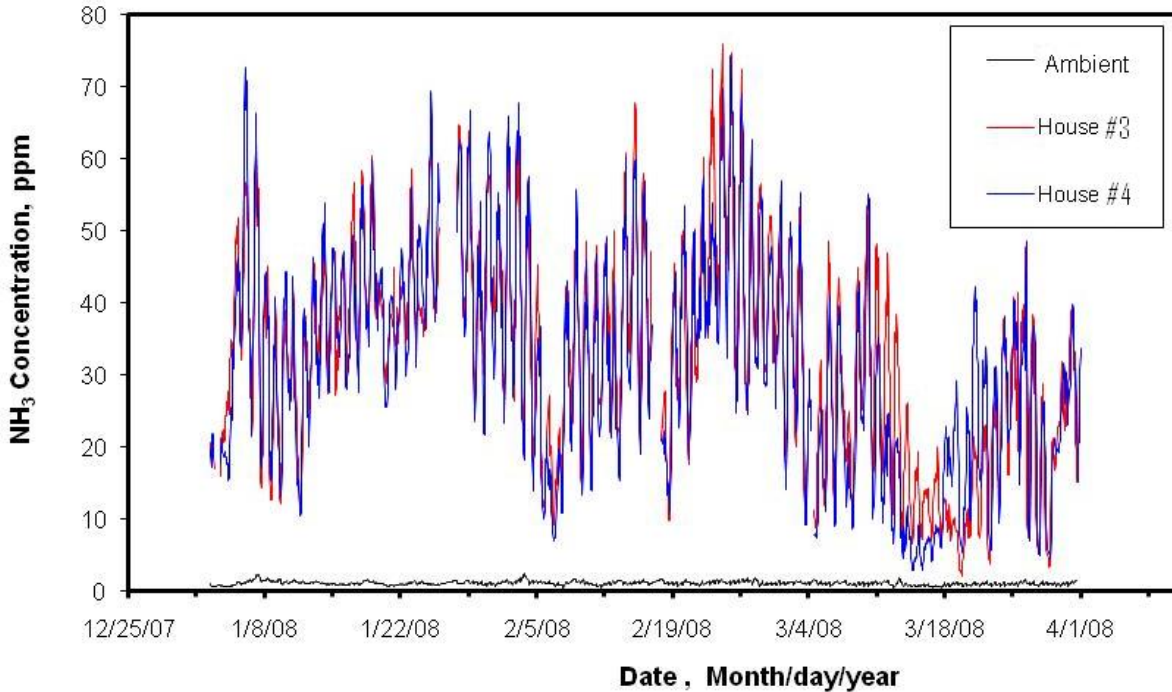


## RESULTS AND DISCUSSION

### NH<sub>3</sub> Concentrations at the Ventilation Fans inside the Houses

The daily mean in-house NH<sub>3</sub> concentrations (Figure 2) ranged from 4.6 to 72.5 ppm. Under the NAEMS, in addition to NH<sub>3</sub> concentrations, in-house air temperature, ventilation rate, and over 100 other variables were simultaneously monitored. As expected, the temperature and ventilation rates showed a strong influence on daily mean NH<sub>3</sub> concentration.

Figure 2: Daily mean NH<sub>3</sub> concentrations: in-house vs. ambient (at air inlet of the houses)



### NH<sub>3</sub> Concentrations at the Sampling Sites around the Farm

As indicated in Table 1 and Figure 3, there were significant spatial variations in NH<sub>3</sub> concentrations among locations. The mean NH<sub>3</sub> concentrations ranged from 0.20 (location S#6) to 0.58 ppm (location S#1) (Table 1). Location S1 was defined as the source point (as shown in Figures 1 and 3), and it had the highest NH<sub>3</sub> concentration of 0.58 ppm. Location S#6 was approximately 1200 m from source S#1 and it had the lowest NH<sub>3</sub> concentration (mean=0.20 ppm). Comparing with some local NC cities average NH<sub>3</sub> concentrations (Clinton: 5.32 μg m<sup>-3</sup> ≈ 7.2 ppb, Kinston: 2.46 μg m<sup>-3</sup> ≈ 1.7 ppb, and Morehead: 0.58 μg m<sup>-3</sup> ≈ 1.2 ppb).<sup>11</sup> NH<sub>3</sub> concentrations near this AFO facility are significantly higher, in the range of 0.2-0.58 ppm (200-580 ppb).

Through the observations of these initial data, it is suspected that concentration of NH<sub>3</sub> could fade rapidly in a short distance. By using a linear regression model, the following empirical equation was obtained:

$$C_{\text{NH}_3} = -0.048 \ln(x) + 0.58$$

$$R^2 = 0.80$$

where:

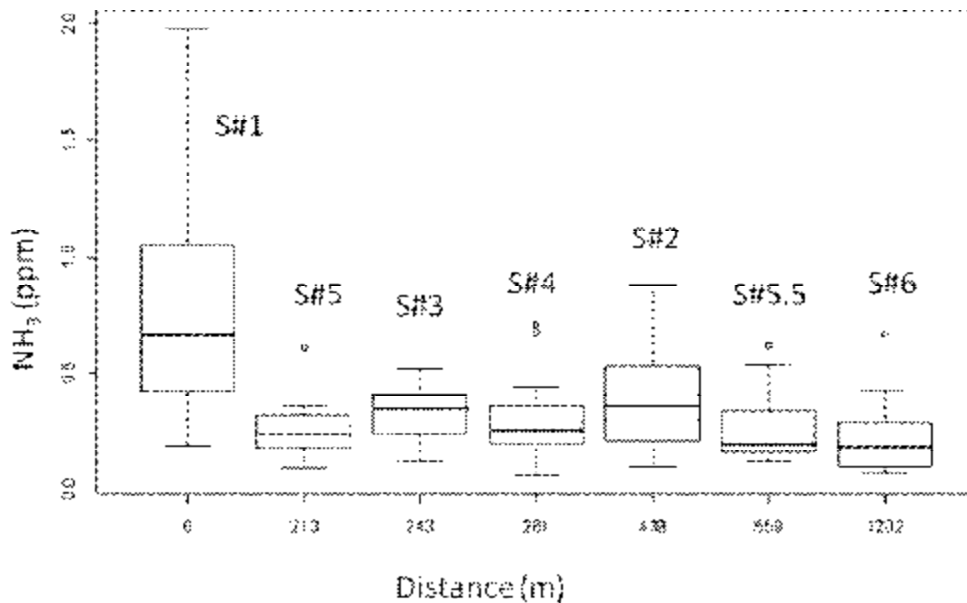
$C_{\text{NH}_3}$  = the NH<sub>3</sub> concentration (ppm)

x = the distant from source in unit meter (m).

Table 1. Mean NH<sub>3</sub> concentrations at different sampling locations

Location	S#1	S#2	S#3	S#4	S#5	S#5.5	S#6
Samples (n)	9	13	13	13	13	13	13
Mean (ppm)	0.58	0.40	0.34	0.29	0.26	0.26	0.20
Minimum (ppm)	0.19	0.10	0.12	0.06	0.09	0.12	0.07
Maximum (ppm)	1.05	0.88	0.52	0.65	0.61	0.62	0.43
Std. Dev.	0.32	0.24	0.11	0.16	0.13	0.16	0.11

Figure 3: Mean NH<sub>3</sub> concentrations at ambient locations over 10 sampling events, summer 2008



## SUMMARY

Ammonia (NH<sub>3</sub>) has great potential impact on the formation of secondary PM. Investigation of the fate and transport of NH<sub>3</sub> emitted from AFOs can provide a better understanding of secondary PM formation in the surrounding ambient atmosphere. The information gathered is important for evaluating possible public PM exposure in the vicinity of the AFOs.

Preliminary results of this study indicate that there are significant differences in NH<sub>3</sub> concentrations at various upwind and downwind distances in the vicinity of a commercial layer farm. NH<sub>3</sub> concentration was observed to fade significantly in a very short distance.

Further investigation is ongoing and variations of NH<sub>3</sub> concentrations will be linked to the formation of secondary PM in the vicinity of this layer farm.

## ACKNOWLEDGEMENTS

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