P1.23 APPLICATION OF OPEN-PATH TDL ANALYSERS FOR DETERMINATION OF METHANE AND AMMONIA EMISSIONS FROM LIVESTOCK FACILITIES

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1. INTRODUCTION

The Canadian agricultural industry releases 60.5 Mt of carbon dioxide equivalent each year, accounting for 8.3% of the GHG emitted from all Canadian sectors. Within the agricultural sector 38% of the GHG released is attributed to methane (CH_4) from livestock, mostly related to enteric fermentation in ruminant cattle. Diet plays an important role in enteric methane production. Mitigation strategies for methane have been based on a variety of measurement techniques, most of which are far removed from the actual production situation. For example, measuring enteric methane production is often done using chambers, hoods or masks (Boadi et al. 2002; Moss 2002).

Like that of CH_4, ammonia (NH_3) is also emitted from the livestock sector in vast quantities (Isermann 1994). Ammonia emissions are also related to diet where the excess nitrogen is excreted as ammonium in the manure. Ammonia has been linked to environmental and health concerns such as the formation of particulate matter in some confined air sheds.

Many of the existing techniques restrict the natural environment of livestock, causing potential bias in measurement of emissions. Monitoring emissions from a variety of commercial production facilities would allow better understanding of the variability in emission factors. One application of these data would be to provide insight on the uncertainty of using single factors for gas emission inventories.

Some whole-farm measurements have been made for methane emissions (Kinsman et al. 1995; Jungbluth et al. 2001). However, these measurements have employed mass balance techniques that are difficult to deploy at a wide variety of farms.

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The objective of our study was to develop and test a monitoring system that used existing technologies to allow rapid evaluation of CH_4 and NH_3 emissions at a farm level.

2. MATERIALS AND METHODS

A mobile measuring unit (Fig. 1) was constructed and consisted of open-path CH_4 and NH_3 lasers (Boreal Laser Inc, model GasFinder) for measuring concentration between the laser and a retroreflector. The CH_4 and NH_3 lasers had a sensitivity of 1 and 5 ppmm (parts per million meter), respectively. Mounted on the tower on the mobile unit were a 3-dimensional sonic anemometer (Campbell Scientific Inc., model CSAT3), air temperature/humidity sensor (Campbell Scientific Inc., HMP45C) and air pressure sensor. All sensors were connected to a datalogger (Campbell Scientific Inc., models CR10X and CR23x) that calculated 30-min averages. The sonic anemometer data were put through a coordinate transformation prior to calculating the stability (Monin-Obukhow length). These data were used to drive a backward Lagrangian Stochastic (bLS) dispersion model (Flesch et al. 1995). The commercially available bLS model software (Thunder Beach Scientific, WINDTRAX) running on a laptop read the output from the CR23X (linked to CR10X) directly and generated real-time flux emissions.

In a preliminary test, the source of methane was two isolated pens of cattle (15 x 15 m; 30 m apart). Each pen contained 18-19 steers. An integrated horizontal flux technique (IHF), using lasers mounted downwind at four levels on the perimeter of each pen, was used to determine the flux from each pen. The trailer containing the bLS instruments was positioned ~50 m away from the pens in the downwind plume.

The mobile unit was also set up downwind of a dairy barn to characterize the plume stability, wind speed and direction, and line concentrations of CH_4 and NH_3. This work began on June 24 2004 with the intention of understanding the range in emission factors from a variety of dairy operations.

3. RESULTS AND DISCUSSION

In a preliminary test of the bLS technique, fluxes generated with WINDTRAX from two isolated pens of steers were strongly correlated (R^2 = 0.94) against measurements made at the pens using IHF technique. Although the precision of the bLS technique (against IHF) was good, there was a deviation from the 1:1 line, where the bLS overestimated relative to the IHF technique.

The mobile unit for the bLS was used to monitor plume characteristics from a combined 270 herd dairy barn and manure holding pond. Our daytime emissions were typically higher (400-1000 g cow^{-1} d^{-1}) than the enteric methane emissions reported by others, e.g., Kume (2002) reported values upwards of 300 g cow^{-1} d^{-1}. The contribution of hind-gut fermentation and methane emissions from the manure holding pond (anaerobic conditions) may in part account for the higher emissions in our study.

Fig. 1. Mobile measuring unit for calculating CH_4 and NH_3 fluxes from whole farm systems.

4. CONCLUSIONS

Preliminary results from this study indicate that the bLS technique used in conjunction with WINDTRAX software is a useful technique for calculating fluxes from complex farm facilities. It allows easy and quick assessment of these fluxes at the whole farm level without disturbing the farm operations. A restriction of the technique is the necessity to be far away from the complex wind patterns associated with the barn and farm buildings.

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